RECREATIONAL IMPACT OF MULTI-PURPOSE RESERVOIRS

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by

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PURDUE UNIVERSITY
LAFAYETTE INDIANA

Progress Report

RECREATIONAL IMPACT OF MULTI-PURPOSE RESERVOIRS

To: G. A. Leonards, Director
Joint Highway Research Project

August 4, 1967

File: 3-3-37

From: H. L. Michael, Associate Director
Joint Highway Research Project

Project: C-36-54KK

The attached research report entitled "Recreational Impact of Multi-Purpose Reservoirs" is a progress report on the HPR research project of similar title and is a final report on Phase I of this research. The report has been authored by Mr. J. S. Matthias who also used it for his PH.D. dissertation. Professor W. L. Grecco has directed the research and supervised the preparation of the report.

The result of this research is a model for the prediction of recreational trips to new reservoir areas in Indiana. The model utilizes road distance, county population and the influence of other similar facilities as the parameters affecting attendance. A technique was developed and is described in the report illustrating how the model can be used to predict future attendance and traffic volumes to recreational areas at multi-purpose reservoirs.

The results of this research will also be presented to members of the State Department of Natural Resources and to the Water and Mineral Resources Advisory Council of Indiana. It is requested that copies of the report be released for submission to these two groups.

The report will also be forwarded to the Highway Commission and to the Bureau of Public Roads for review and acceptance as fulfillment of the objectives of Phase I of this research. A proposal to continue this research into Phase II to include an evaluation of growth trends of recreational use, the use of gasoline fuel by motor boats, further verification of the model and other aspects will be submitted at an early date.

This report is submitted for the record.

Respectfully submitted,

Harold L. Michael

Harold L. Michael
Associate Director

HLM:slj

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Progress Report

RECREATIONAL IMPACT OF MULTI-PURPOSE RESERVOIRS

by

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File No. 3-3-37
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The author wishes to thank the Joint Highway Research Program of Purdue University and the Indiana State Highway Commission for the financial assistance which, together with the support of the Bureau of Public Roads of the U. S. Department of Transportation, made this research possible.

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ABSTRACT

Matthias, Judson Stillman, Ph. D., Purdue University, August 1967. Recreational Impact of Multi-Purpose Reservoirs. Major Professor: William L. Grecco.

This thesis reports the results of a study concerned with the development of a model that can be used to predict recreational trips to new reservoirs in Indiana.

The Model developed utilizes only road distance, county population, and the influence of other similar facilities as the parameters affecting attendance. A technique was developed illustrating how the model can be used to predict future attendance and traffic volumes.

Three parks, Raccoon State Recreation Area on Mansfield Reservoir, Lieber State Park on Cagles Mill Reservoir, and Monroe State Park on Monroe Reservoir were used in the study. Data were collected by conducting interviews of twenty-five percent of arriving trips at the park entrances. Over 13,000 interviews were conducted over a two year period. Yearly distributions of trips by trip purpose and frequency were investigated.

The prediction model was developed by using non-linear regression analysis to determine the parameters of distance, population and the influence of other parks. Two equations were developed, one for the condition where there is no other park closer to a county than the park under consideration and the other for the condition where there is another park closer to a county than the park under consideration. Together, the two equations constitute the prediction model.

INTRODUCTION

The control and use of water resources is and will continue to be of major importance to the economic life of the United States. Flood control, irrigation, and hydro-electric power were originally the three purposes considered in the cost analysis for justification of the construction of dams and their resulting reservoirs. However, not until recent years have the recreational benefits been generally included in the economic analysis or even recognized as an economic factor.

Recreation is now recognized as big business in this country. A substantial portion of the Gross National Product is devoted to recreational pursuits in all areas of the nation.

Traffic patterns have changed because of the proportionate increase in personal expenditures for recreational purposes. Many rural highway sections serving recreational facilities now carry their peak travel loads on weekends.

The development of the future highway network must take into account the traffic generating abilities of a recreational park on a reservoir. A recreational facility is of little value without access. On some routes, peak volumes result from trips made for recreational purposes. On many routes, weekend traffic volumes exceed the weekday volumes and the increase is due mainly to recreational travel(1).*

Future highway planning must take into consideration the traffic generating capabilities of this type of recreational facility. There

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* Numbers in parentheses refer to entries in the List of References.

is no point in having a well developed park that is difficult to reach: the public will not go to such a park in numbers great enough to properly utilize the investment made in developing the park.

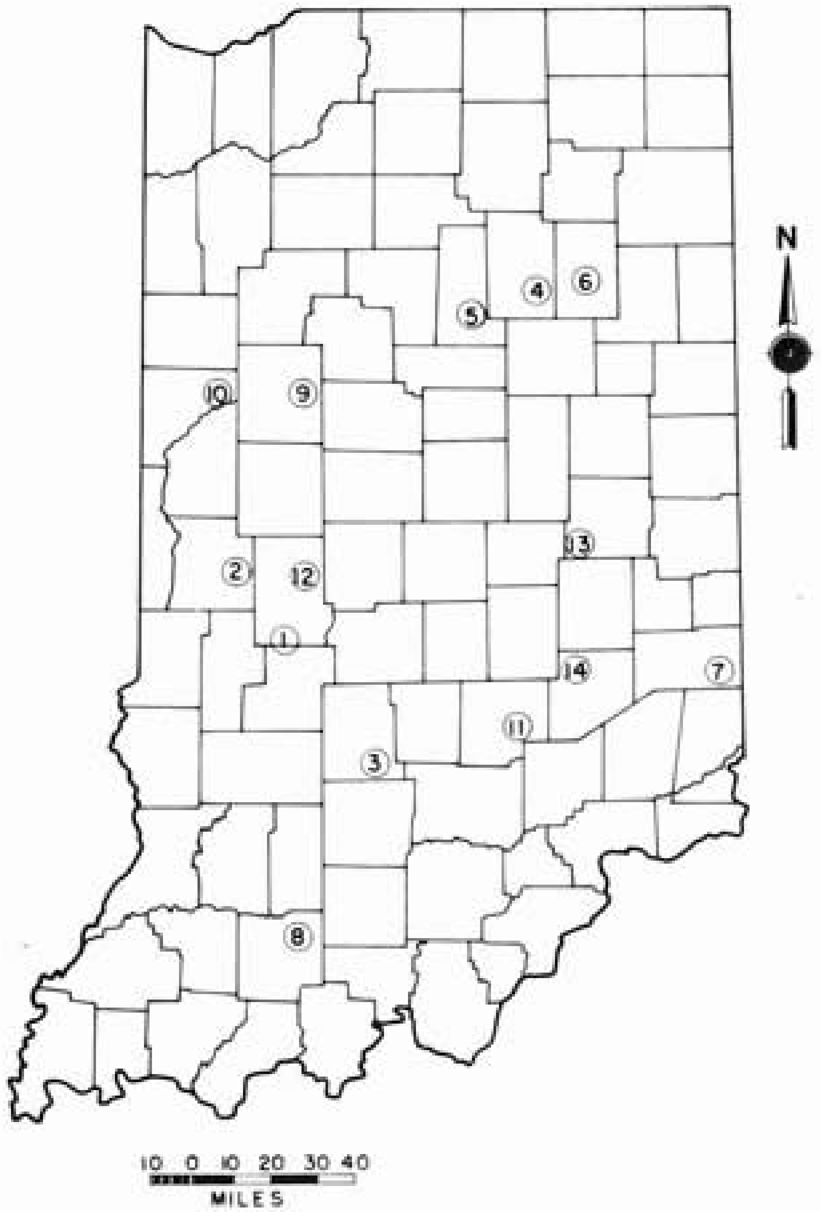
Water is a recreational magnet and will attract large numbers of people for recreational purposes. The multi-purpose dams and their reservoirs are therefore natural recreational attractions and consequently traffic generators. The recreational potential of a reservoir cannot be fully utilized unless transportation planning coincides with reservoir development plans so that an adequate transportation system is available as the recreational demand grows. The agencies responsible for planning must have some means of determining demand prior to construction so that the best use can be made of the available resources of land and money. At the present time, little factual information is available that can be used by planners to estimate the recreational demand. Many reservoir sites are located in areas with poor existing transportation facilities. Usually existing roads were designed for rural traffic of low volumes, and as such these roads cannot begin to accommodate the traffic generated by a reservoir and its attendant recreational facilities.

PURPOSE AND SCOPE

The flood control projects that have been and are being developed within the State of Indiana have produced and will produce many reservoirs which are suitable for recreational purposes (see Figure 1). The State Department of Natural Resources is responsible for the development and operation of recreational facilities at such reservoirs. Very little information is available for planning recreational facilities at reservoirs. No one can accurately say how sites are needed to satisfy the demand for recreation in a given area. No one knows what effect a reservoir park has on attendance at another park in the same general area.

The Indiana Department of Natural Resources early in 1965 asked the Joint Highway Research Project at Purdue University to conduct a research program that would develop information that could be used as tools for planning recreational developments at future reservoir sites. Three reservoirs were suggested for study, two had been in operation for several years and the third was in the process of being opened for public use although few facilities were available. The two developed parks are Lieber State Park on Cagles Mill Reservoir and Raccoon State Recreation Area on Mansfield Reservoir. The third park is located on Monroe Reservoir.

A proposed research program was submitted to the Joint Highway Research Board, funding for the project was provided by the Bureau of



MAJOR PROJECTS

COMPLETED	UNDER CONSTRUCTION	AUTHORIZED	PLANNED BUT UNAUTHORIZED
1. CAGLES MILLS	5. MISSISSINEWA	8. PATOKA	12. BIG WALNUT
2. RACCOON	6. HUNTINGTON	9. LAFAYETTE	13. BIG BLUE
3. MONROE	7. BROOKVILLE	10. BIG PINE	14. DOWNEYVILLE
4. SALAMONIE		11. CLIFTY CREEK	

REPRODUCED FROM "THE INDIANAPOLIS STAR" - SUNDAY, APRIL 23, 1967

FIGURE I
RESERVOIRS

Public Roads of the U. S. Department of Transportation and the Indiana State Highway Commission through the Joint Highway Research Project. The purpose of the research is to develop a method that can be used to predict recreational attendance at planned reservoirs based on the characteristics of the recreational facilities, population, the distance from population centers to the planned reservoir, and the influence of other reservoirs in the vicinity of the planned reservoir. The determination of the growth patterns of attendance at new facilities as compared to established reservoirs is a secondary objective.

The park facilities at the reservoirs are similar in type. Boat launching ramps at various locations around the reservoirs are provided; five at Raccoon, two at Cagles Mill, and nine at Monroe. Each boat ramp is provided with paved roads, appropriate parking area, and usually picnic grounds. These ramps may or may not be located in the main park.

Raccoon and Cagles Mill each have one beach several hundred feet long. Swimming is permitted only at the beaches which have adequate life guard personnel and control equipment as well as diving boards and bath houses. Monroe has or will have two beaches operated by the State of Indiana and one operated by the U. S. Forest Service. All are similar to the ones at Raccoon and Cagles Mill.

Within the main park at Raccoon and Cagles Mill are located the camp grounds, beaches, concession stands,boat rentals, picnic areas, and bathhouses. There are hiking trails available. In general, each park is well kept by personnel who know and take pride in their work. The recreational facilities available at each park are similar and it is difficult to visualize what additional types of facilities would be useful at this type of park.

The need for outdoor recreational areas can only increase. The Midwest as a region has 29 percent of the population of the 48 contiguous states, but only 12 percent of the recreational acreage [2]. The use of flood control reservoirs for recreational purposes can provide a substantial portion of the needed public recreational areas and every effort should be made to utilize such areas in the most efficient manner for the benefit of the public.

Proper utilization of these facilities will require an adequate highway system. The purpose of this research was to provide a simplified method for estimating future traffic volumes for new facilities of this type.

RELATED WORK

One of the more interesting developments of society in the years following World War II has been the large increase in travel for outdoor recreational purposes. The Outdoor Recreation Resources Review Commission has published a lengthy and detailed analysis of present and future outdoor recreation in the United States [2].

The main report and its 27 study reports are an excellent source of information on current and future recreation needs as well as the characteristics of the population that utilizes outdoor recreation. The report shows the patterns of the demand for outdoor recreation in terms of type of recreation, age of population, economics, and other factors. The study also lists the locations of recreational resources, areas where more facilities are needed, and those activities which are most popular.

The entire report is an excellent source of background material; however, for a detailed report on a specific problem such as this research, it does not contain the type of information that is readily convertible into trip generation data.

Many other reports such as "The Automobile and Recreation" by Lovelace, point out the necessity for planning recreational facilities and the need for coordinated transportation and recreational planning [3]. There are few reports that have specifically dealt with the problem of forecasting trips to a type of recreational park such as a reservoir lake.

Population growth is responsible for some of the increase in outdoor recreational travel but it cannot account for all of it. The growth of the population alone will cause a large increase in the number of recreation trips even if there is no growth in the recreation trip rate due to other factors. Most population projections indicate that the population of the United States will approximately double within the next 40 years. If all other factors remain constant, and this is an assumption that appears most unlikely, the number of recreation trips will also double with the same growth rate as the population growth rate.

Personal income is another factor that affects recreation trips. This factor has also shown a steady rate of growth in the last 20 years. A growth in personal income means a corresponding growth in the amount of income that is available for recreation or, in other words, a growth in the amount of disposable income, some of which is devoted to recreation. People are spending money for recreational equipment as never before. The growing number of pleasure boats, camping trailers, tents, and related items is clear evidence of increasing consumer interest in outdoor recreation and of the increasing means available for recreation.

The time available for recreation is also increasing. The length of the work week is decreasing; around the turn of the century the average work week was about 60 hours, by 1960 the average had fallen to 40 hours and the trend toward even shorter work weeks continues. Much of the time saved from the decrease in working hours is devoted to recreational pursuits. Of course, not all leisure time is devoted to outdoor recreation but at least one-fifth is and there is no reason to suspect that this relationship will decrease in the future (2). In fact, as the available leisure time increases, more of the leisure time will probably be devoted to outdoor recreation and longer trips will be possible.

The automobile has had an impact on recreational travel. The number of passenger cars estimated for 1976 is 100,000,000, nearly 80 percent more than the number available in 1952 [(3)]. The mobility of the population is increasing and as a result, more people with more money buy more cars and spend more money for recreation. The increasing improvements to the highway networks by means of such programs as the Interstate Highway System will provide quicker access to more areas for more of the population. As a consequence, longer trips will be possible in the same time space as is required for today's trips. This means that a recreational trip will be able to reach more recreational areas than ever before. Recreational trips will become more frequent and of longer duration.

Unfortunately, the amount of information available for recreational planning is not adequate. There is a need for a relatively simple, accurate method that can be used to predict attendance at a recreational site before the facility is built. The need for information on the growth rate of recreational trips to a particular type of recreational area is needed.

Smith and Landman developed a gravity type distribution model and an opportunity type distribution model to predict attendance at reservoirs in Kansas [(4)]. These models require the use of an equation to predict county trip production based on several socio-economic factors as well as reservoir and distance characteristics. The form of the gravity model used by Smith and Landman is:

$$T_{ij} = \frac{P_i\ A_j\ F(d_{ij})\ K_{ij}}{A_1\ F(d_{i1})\ K_{i1} + \cdots\cdots + A_n\ F(d_{in})\ K_{in}}$$

Where T_{ij} = number of trips from county i to reservoir j

P_i = total trips produced by county i

A_j = total trips attracted by reservoir j

d_{ij} = spatial (distance) separation of county i and reservoir j

$F(d_{ij})$ = an empirically derived distance factor

K_{ij} = county to reservoir adjustment factor (assumed to be unity)

The form of the opportunity model used is:

$$T_{ij} = P_i(e^{-LA} - e^{-L(A-A_j)})$$

Where e = base of natural logarithms

L = measure of probability that a random destination will satisfy the needs of a particular trip

A = sum of destinations already considered.

The problem of finding the proper "L" value was solved by determining the "L" value required to reproduce one trip interchange between one county and one reservoir. Subsequent values of "L" were found by iterative techniques. Both the gravity models and the opportunity models require a balancing procedure in order to distribute the trips.

Trip ends for a county were produced by means of the following multiple regression estimating equation:

$$Y = 772.88546 - 12.124483(MA) - 0.0869617(MFI)$$
$$- 0.0025965(RS) - 0.0161747(UP\ MA,\ D_1{}^{-1.5})$$
$$- 0.015977(UP\ MS_2D_2{}^{-1.5}) - 0.0130234(UP\ MS_3\ D_3{}^{-1.5})$$
$$- 507.92844(A_1\ XD_1{}^{-1.5})^2 - 1661.0105(A_2\ D_2{}^{-1.5})$$
$$1406.1434(A_3\ D_3{}^{-1.5})$$

With $R^2 = 0.9386$

where MA = median age of the county population

MFI = median family income

RS = retail sales in thousands of dollars

UP = urban population

MS_x = miles of shoreline of reservoir x

A_x = area in square miles of reservoir x

D_x = dogleg distance to reservoir x

x = subscript denoting first, second, or third closest reservoir.

An equation for estimating the trips attracted to a reservoir is as follows:

$$Y^{1/2} = 10.254350 + 0.092119760(\text{Picnic Grills})$$
$$+ 0.54573830\ (\text{Area in Square miles of summer pool level}) + 0.13347861\ (\text{Road Development Factor})$$
$$+ 0.039874330\ (\text{Population within 50 miles})$$
$$+ 0.028432290\ (\text{Population in the 50-100 mile range})$$

$R^2 = 0.9637$

When Y = trip ends to the reservoir

$$\text{Road Development Factor} = \frac{\Sigma\ (K \times \text{miles of road})}{\Sigma\ (\text{miles of road})}$$

and where $K = 1.0$ (asphalt)

1.5 (gravel)

2.0 (earth)

Population is in thousands of persons and miles of road is road distance from the centroid of the dam to each major reservoir area.

Similar equations were developed for the attractive indices for the gravity and opportunity models.

The compilation, correlation, and use of some of the data are tedious. According to the authors, some of the coefficients of the regression equations used to predict trip ends appear contrary to reason.

While the distribution models used are accurate and reflect a clear appreciation of the problems involved, the method is somewhat unwieldy in that so many factors need to be determined before trips can be distributed from a county to a reservoir.

In a study of weekend recreational trips to parks in Indiana, Schulman used a single exponent gravity model in order to predict trip distributions (5). In establishing the relative attraction of each county, he used county population as the only variable. In contrast, Smith and Landman used many socio-economic factors which are difficult to forecast. Population seems to be the best single estimator of the county's attractiveness and the easiest to obtain. Schulman's work was concerned with the State parks of Indiana and as a consequence, the park characteristics varied widely.

The gravity model used is of the form:

$$T_{ij} = \frac{T_i \times \dfrac{R_j}{(D_{ij})^x}}{\displaystyle\sum_{j=1}^{n} \frac{R_j}{(D_{ij})^x}}$$

where T_{ij} = number of trips from an area j to a recreational area i

T_i = number of trips attracted to recreational area i from all residential areas

D_{ij} = road distance from area j to area i

x = exponent which is determined for the type of recreational trip under consideration

R_j = measure of the number of recreational trips generated from county j.

In order to determine the constants for this form of the gravity model, four quantities had to be determined:

T_j = number of recreational trips generated by county j

T_i = previously defined

T_{ij} = previously defined

D_{ij} = previously defined.

A linear multiple regression model was used to predict the number of trips to a park:

$$\begin{aligned} Y = {} & 903.55 + 6.14\, x_1 - 5.80\, x_2 + 35.98\, x_3 + 2.20\, x_4 \\ & - 646\, x_6 - 2.63\, x_9 + 726.48\, x_{12} - 430.02\, x_{17} \\ & + 217.72\, x_{18} + 0.11\, x_{19}.^* \end{aligned}$$

$R_2 = 0.8569$ Standard error = 309

where Y = total weekend trips to a park

x_1 = number of picnic tables

x_2 = number of camp sites

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* Some of the coefficients are different from the original work, the changes were made to correct printing errors.

x_3 = area of lake (in hundreds of acres)

x_4 = area of park extensively developed (in acres)

x_6 = availability of a bathhouse

x_9 = capacity of total living facilities (in guest-nights)

x_{12} = availability of fishing

x_{17} = location on a river

x_{18} = availability of electricity

x_{19} = population (in thousands) within 60 miles of the park.

The parks were not necessarily located on a lake or reservoir although both Raccoon and Cagles Mill were included in the parks studied. Some of the parks were located on rivers or streams while others had no water related facilities. The consideration of dissimilar types of parks required the inclusion of many variables which do not apply to all of the parks and which may or may not be pertinent for trip predictions for a specific park.

A report by Ungar recognizes the major problem of this type of analysis: the lack of adequate data (6). The methods require the collection of a great deal of information which should be kept current as projections must be made for each data item for future trip predictions. Neither Ungar nor Schulman made an attempt to evaluate the effects of competing parks.

Ungar used an Activity Index developed by Mueller and Gurin which is based on a multiple classification analysis using socio-economic and trip frequency data (7). He states that further work is needed on the activity index before any final judgment of its value can be made.

Ungar's multiple regression equation for trip generation by a park is a modification of Schulman's. The trip distribution models investigated by Ungar are all variations of the basic Gravity Model type. The Activity Index developed for this study is based on the characteristics of male heads of families and single male adults. This was based on the assumption that almost all trips to parks are headed by male adults. The purpose of the Activity Index is to indicate the relative frequency of participation (or number of trips) as compared to an average.

The Activity Index is expressed as:

$$Ah = \sum_{k} \frac{a_{hk} P_{hk}}{P_h}$$

where Ah = weighted component of the activity index

k = subclassification of h (referring to education for example)

P_h = male population of a county

h = factor

a_{hk} = component of the activity index in the h_1k subclass.

Activity index components were developed for each county studied and included the following characteristics: income, education, occupation, paid vacation, place of residence, region (of county), age, race, and life cycle. Life cycle was defined by marital status, age, and number and age of children.

The regression equation for park attractiveness is as follows:

$$\begin{aligned} Y = &- 432.8 + 4.14T + 10.81L + 80.67H - 0.0032T^2 \\ &+ 0.0130L^2 - 12.07A^2 - 0.0367TL + 0.00736TS \\ &+ 0.0236LS - 0.219HS. \end{aligned}$$

With multiple correlation = 0.988 and standard error = 178 trips.

The use of regression analysis techniques to relate attendance to park characteristics is attractive and has been pursued by the investigators already mentioned. However, many of the characteristics that are involved in the regression analysis are not truly quantitative such as amenities used by Ungar.

The use of regression analysis techniques requires the assumption that attendance is dependent upon the number or quantity of a certain item such as picnic tables. It is questionable if the exact number of picnic tables will cause any significant flucuation, if any, in the number of visits to a large park such as Raccoon or Cagles Mill. Rather the fact that a suitable and pleasant area for picnics is available is more significant than the number of picnic tables or grills. It is doubtful that visitors are conscious of the number of any type of item. If there is space available at the beach, in the campground, or space for a picnic, they will be satisfied.

In this project a single type of recreational facility is considered, the State park located at a multi-purpose reservoir. All such parks in the State of Indiana have or will have similar characteristics although the amount of each type of facility may vary depending on the amount of land available for recreational purposes. This will, no doubt, depend to a large extent on the size of the summer pool level of the reservoir. The parks will be located on a lake of over 1000 acres or larger. The facilities at each park will be essentially the same in type and quality.

The parks will attract trips from all types of areas, urban and rural, as well as from all socio-economic groups. In any area, 125 miles in radius the percentages of the various socio-economic groups would be approximately the same. As a result these factors need not be significant for the purpose of this study. They should not affect the attendance at one park as opposed to attendance at any other similar park in the same region.

What is needed then is a method that can be easily understood by all concerned planning groups. The method should be useful, accurate enough for long range planning, responsive to changing rates, and it should be based on easily measured and readily available parameters.

DATA COLLECTION

In order to acquire sufficient data for the study, collection was made over a period extending from June, 1965 until October, 1966 at all three parks. Figure 1 shows the location of the three reservoirs. Data collection was begun early in the planning stage of the project in order to tak full advantage of the summer session of 1965. However, because data collection began prior to the development of a thorough plan of analysis, more information was obtained than was actually used.

The primary source of data was a 25 percent interview of vehicular trips arriving at the parks. The 25 percent sample was considered adequate for analytical purposes and did not create a disruption in traffic flow. The interviews were conducted at the gate houses where arriving vehicles were required to stop and pay fees. Each interview took approximately 20 seconds.

The number of Indiana passenger car licenses includes the number of the county of residence of the listed owner. This was recorded and used as the county of origin for the trip. The driver was asked the purpose of the visit; the number of adults and children were determined. Children were considered to be persons under 12 years of age since no charge is made for admittance of persons under 12. Note was made of any equipment carried such as a boat, house trailer, or camping trailer. Time of day, date, park and place of entry (main gate or isolated boat ramp) were recorded. See Appendix A for data collection sheet.

Several problems were soon apparent. Out of state cars were occasionally encountered. Drivers of such vehicles were asked if they were passing through or were visiting in the area. Visitors to Illinois or Indiana were considered to be trips originating from the county visited. Vehicles displaying decals from schools or military bases in Indiana were considered to be trips from those locations regardless of the state or county indicated on the license plate.

The interviews were conducted at the gatehouses at Raccoon and Cagles Mill. No gatehouses were in operation at Monroe during this period. The advantage of conducting interviews at the gatehouses was that the vehicles were already stopped in order to pay fees, and no further disruption of traffic was necessary. Also, it was possible to determine which vehicles had already paid and thus duplication of interviews was prevented. Vehicles on park business were not charged admission and were not included in the sample. It was therefore possible to exclude all those vehicles which were not entering the park for the first time. Unfortunately this was not possible at the boat ramps at Raccoon or Monroe. However, the volumes at the boat ramps were low enough so that it was possible to ask if the trip had entered the park previously, without causing an undue delay to traffic. At Cagles Mill there is an attended gatehouse at the only isolated boat ramp.

The majority of the interviews were conducted over the weekend periods, from Friday afternoon to Sunday afternoon during the summer months. Weekends were selected randomly. During 1965, the parks were visited every two weeks beginning early in June and continuing through August. Raccoon was visited one weekend and Cagles Mill and Monroe the next weekend throughout the summer. Periodic visits were made during the fall and winter and also during the spring of 1966, in order to determine the yearly distribution of trips. During the 1966 summer season visits were made to each park every third weekend. Weekday visits were made in June and August only.

The general procedure for weekends was to begin at 2 PM on Friday and interview until 9 or 10 PM. On Saturdays, interviewing would begin at 9 AM and continue until 8 PM. On Sundays, interviewing would begin at 9 AM and continue until 5 PM. The hours were selected on the basis of observation made at Raccoon Park. After about 9 PM on Fridays, few arrivals were noted, and few arrived before 9 AM on any day of the week. The parks were open 24 hours a day during the summer, but interviews were conducted only during the stated hours. The park records on attendance showed that on weekends the arrivals during the interview period usually accounted for about 90 percent of the total visitors on Saturdays and Sundays and about 75 percent on Fridays. Weekday interviews were conducted in essentially the same manner as were the weekend interviews.

After the 1965 summer season was over, a random selection of 5 percent of the samples were mailed questionnaires. The questionnaires (See Appendix A) were concerned with the number of visitors who were repeaters, that is, people who came regularly to the park. Return postage and envelopes were provided. The addresses were obtained from the license plate data available from the State of Indiana, Department of Motor Vehicles. About 40 percent of the questionnaires were returned.

Preparation of Data

The data were summarized by means of the IBM 7094 Computer utilizing Fortran IV computer language. The large number of data items precluded any attempt at hand calculation. Thirteen thousand three hundred and forty samples were collected by the interviews. The summation program that was developed is included in Appendix B.

The program permitted the summation of any of the separate items of a sample in any desired manner. Each item could be counted on the basis of any other item by means of logical IF statements. The summation program was found to be very flexible and useful. The output format was designed so that the same information was available for each park and year simultaneously with the trip purpose.

Since the visitors were asked to state the purpose of their visit, many multiple purposes were stated. This was not unusual. It is probable that most trips to a reservoir are made for more than one purpose. However, in this study,only the stated purposes were recorded since these were considered to be the purposes which inspired the trip. No effort was made to determine if, in fact, the stated purposes were actually accomplished. The fact of interest was what attracted the visitor to the park, not what he actually did once he had arrived at the park. The trip purposes considered were boating, camping, fishing, picnicking,swimming, hiking, looking, and others.

Some trip purposes were not compatible with multiple listing. Looking and other categories were not listed with multiple purposes. For instance, a trip purpose given as "boating and looking around" was classified only as "boating." A camping trip which also lists picnicking as a purpose does not logically make sense, as an overnight camping trip without meals is hardly feasible. Some of these trips (camping and picnicking)may have appeared on the summation sheets but they were summed with the camping trips for analytical purposes. A trip for which boating and swimming were given as the reasons for making the trip could not justifiably be counted as boating rather than swimming or vice versa as no justifiable reason existed for making an arbitrary judgment as to what category in which to place the trip. A multi-purpose trip of swimming and boating could not be listed as both a swimming and a boating trip. The solution to this problem was to list each trip as a separate entry. In this example, the trip could be listed as a boating-swimming trip or BS in the summation program without preference to either activity. This requires 65 trip categories in the summation output. The result is that each trip is listed only once and is completely described in terms of the stated purpose(s) as listed by the visitor. This solution permitted the computation of any trip type as well as those types contained in multi-purpose trips.

For example, a desired summation of boating trips could be made up of all single purpose boating trips (where boating was the only purpose listed) and all multi-purpose trips of which boating was listed as one of the purposes for making the trip.

The summation program was used to determine the trips to each park for each year from each county in Indiana and Illinois as well as from other states. The trips from each county could be determined also by type, that is, boating trips from each county to each park could be determined. The number of people, or adults and children, could be determined in the same manner as were the number of trips.

The summation program accomplishes nothing more than summing the data based on any factor or combination of factors desired. The factors available are listed in Table 1.

Each interview sample was entered on a single IBM card. For analytical purposes, the "looking" and "other" categories were combined because it was felt that there is really no difference between the two. The "other" category includes all purposes not included in the remaining categories. "Looking" category essentially includes those trips for which no satisfactory purpose could or would be stated. This category might include the casual driver, driving for pleasure, or simply impulse visitors who were driving by and decided to visit "to see what is there." The number of "looking" trips is large compared to the "other" trips. Since both categories are difficult to classify, it was decided to group them together.

When county trip totals were determined, it became apparent that over 80 percent of all trips came from within 125 miles of a park. For the purpose of this analysis, no counties beyond 125 miles of the closest park were considered. The observed trips per county beyond this range were so few as to be insignificant.

In order to standardize the trip rate from any particular county, a unit of measure was required. The unit selected was trips per 1000 population. There is a large variation among county populations. Marion County contains 785,000 people, while Union County contains 6000. Obviously the total number of trips from the two counties will vary

TABLE I

INTERVIEW DATA ON IBM CARD

Item	Column(s)	Remarks
Park	1	1, 2, or 3
Location	3	1-5, 1-2, 1-9
Month	5-6	
Date	8-9	
Year	11	1, 1965 or 2, 1966
Day (of week)	13	1-7, 1, -Sunday - 7, -Saturday
Weather	15	1-4, clear-hot, cloudy-cool, rain, cloudy
Sample percentage	17	1(25% sample), 2(100% sample-winter)
Hour	19-20	
County	22-23	
State	25-26	
Equipment	28	1-boat, 2-house trailer, 3-camping trailer
People	30-31	
Children	33-34	
B(boating)	36	1, if stated, blank otherwise
C(camping)	37	
F(fishing)	38	
P(picnicking)	39	
O(other)	40	
S(swimming)	41	
H(hiking)	42	
L(looking)	43	

even if the distances to a park are the same. The use of a trip rate will tend to normalize the disparity of population differences.

The trips from each county were converted into trips per 1000 population. Observed trips were divided by a factor, called the expansion factor which is the percentage of all trips to a park that were sampled in a year. The total trips were obtained from the Department of Natural Resources' weekly tally sheets which were available for 1965 and 1966. A sampling day is a day of weekday sampling. If a weekend day, Friday, Saturday, or Sunday was used, a multiplier of five was used as weekends days produce about five times as many trips as a weekday day. Therefore, one weekend produces three times five or 15 "sampling days." The total sampling days for each park and year are shown on Figure 2.

The observed trips from a county were multiplied by four to reflect the 25 percent sample. The resulting figure was then divided by the expansion factor from Figure 2, determined from the number of sampling days in order to obtain the total annual trips from that county to a park.

TABLE 2

SAMPLING DAYS AND EXPANSION FACTORS

	1965		1966	
	Sampling Days	(Expansion Factors)	Sampling Days	(Expansion Factors)
Raccoon	107	.287	128	.342
Eagles Hill	79	.210	75	.200
Monroe	75	.200	80	.212

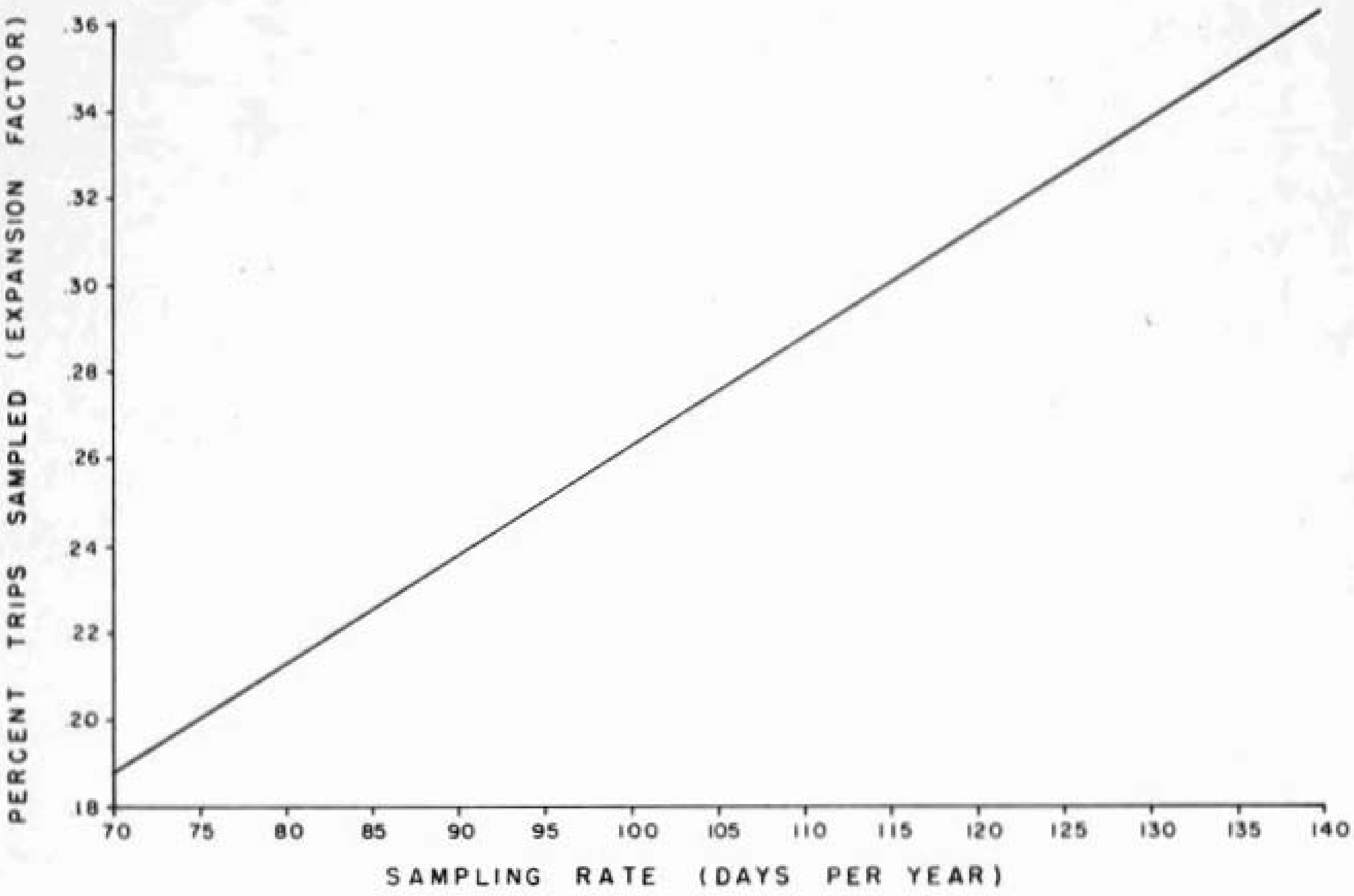

FIGURE 2
EXPANSION FACTORS

By dividing the total trips, or boating, swimming, camping, or picnicking trips by the county population in thousands, the trip rate for any desired trip purposes can be obtained.

The county population data projections for 1965 and 1966 were linear projections of the 1950 and 1960 census data [8]. The trip rates for each county for both years, to all three parks were computed for total, boating, camping, picnicking, and swimming trips.

The distance figures were developed from the center of each county to the center of each park. Road miles were measured using the primary highway system.

ANALYSIS

Development of Prediction Model

A normal plot of the trip rates versus distance of the various counties from a reservoir produced a curved line. A plot of the same data on a semi-logarithmic graph produced a straight line, indicating that an exponential type of function should describe the trip rates in terms of distance. This result was expected since the relationship between trip ~~length~~ rate and distance has been shown to be exponential [9]. The relationship is based on the premise that a trip desires to be as short as possible; a person making a trip for any purpose will usually go no further than is necessary to satisfy the purpose for which the trip is being made.

For determining the trip rate, the function used was:

$$Y = A\,e^{-Bx} \tag{1}$$

where

Y = trips per 1000 population from a county to a reservoir

A = Y intercept of non-linear regression curve

e = base of natural logarithms

B = rate of change of non-linear regression curve

x = distance in tens of miles from a county to a reservoir.

Two regression curves were developed; one curve is to be used for counties that are closest to the specified park and the other curve is for trips to a park that is not the closest. Trips were observed from a particular county to more than one park. If the assumption that a trip desires to be as short as possible is correct, then the characteristics or the parameters of equation 1 should be different for each case. Case one is the condition where there is no park closer to a county than the park under consideration. Case two is the condition where one or more parks are closer to the county than the park under consideration.

In accordance with the above conditions, the counties were separated into two groups for each park. All counties that were closer to the park considered than to any other park were placed into one group. The other group contained all counties that were closer to a park other than the one under consideration.

Monroe was not considered for the purposes of estimating the parameters because the park was not fully operational during this period. No beaches were open for swimming, only extremely limited camping and picnicking facilities were available, and fishing was not permitted. Only boating could be considered to be in normal operation at Monroe. The road network serving the area was inadequate. The roads were narrow, winding, and mostly unpaved.

Counties that are located beyond a distance of 20 miles from Monroe Reservoir were assumed not to be influenced by the presence of Monroe Reservoir but were considered to be closest to Cagles Mill. Monroe Reservoir exerted an influence on the counties that were less than 20 miles away. These counties were included in the intervening group for Cagles Mill and Raccoon. In 1966 Raccoon Park did not permit swimming because the reservoir pool level was too low. For this reason, the 1966 data for Raccoon were not included in this portion of the analysis.

The model $Y = Ae^{-Bx}$ is non-linear in that the function is not linear for the parameters, it is not of the linear form

$$Y = B_0 + B_1 Z_1 + \cdots + B_n Z_n + \epsilon \qquad (2)$$

The estimation of the parameters by the method of least squares can be made by using a logarithmic transformation into the form

$$\ln Y = \ln A - Bx \qquad (3)$$

This approach assumes the errors in the original function are multiplied and are therefore additive in the transformed model. The logarithmic transformation may not give good estimates of the parameters because the transformed model is not the same function as the original [10].

A non-linear regression analysis was used to obtain the parameters A and B. The method selected was a minor variant of SHARE 3094 [11]. This program finds the estimates of the parameters A and B in the function $Y = Ae^{-Bx} + \varepsilon$ by minimizing

$$\Sigma\, \varepsilon^2 = \Sigma(Y - \hat{Y})^2 \qquad (4)$$

where ε is the residual error and $\hat{Y}$ is the estimate of Y. In order to solve $\Sigma\, \varepsilon^2 = \Sigma(Y - \hat{Y})^2$, the partial differential equations of $Y = Ae^{-Bx}$ with respect to the parameters must be used since

$$\frac{\partial(\Sigma\, \varepsilon^2)}{\partial \hat{A}} = -2\Sigma(Y - \hat{Y})\frac{\partial \hat{Y}}{\partial A} = 0 \qquad (5)$$

and

$$\frac{\partial(\Sigma\, \varepsilon^2)}{\partial \hat{B}} = -2\Sigma(Y - \hat{Y})\frac{\partial \hat{Y}}{\partial B} = 0 \qquad (6)$$

are the normal equations which must be solved simultaneously for $\hat{A}$ and $\hat{B}$, the estimates of A and B.

The required partial differential equations were

$$\frac{\partial \hat{Y}}{\partial A} = e^{-\hat{B}x} \tag{7}$$

and

$$\frac{\partial \hat{Y}}{\partial B} = x\hat{A}e^{-Bx} \tag{8}$$

These two equations were substituted into equations 5 and 6. The equations may be solved by finding the values of A and B which will minimize $\Sigma\, \varepsilon^2 = \Sigma(Y - \hat{Y})^2$. This is the method used by the SHARE 3094 program. It is an iterative technique which requires an initial estimate of the true parameters.

The initial parameters used were developed by estimating parameters for a linear transformation of the data for the total trips to Raccoon for 1965 and to Cagles Mill for 1965 and 1966. The results were such that a value of 250 was selected as the initial estimate for A and a value of 0.466 was selected for B. A similar procedure was used for intervening parks with the resulting estimates of 120 for A and 0.466 for B. The values used proved satisfactory as initial estimates. An easier method would have been to select values from a regression line estimated from a plot of the data. This method would have been sufficiently accurate because only two parameters are involved.

Using the data for total trips, a linear transformation of the form $\ln Y = \ln A - Bx$ was made for the purpose of testing if the various regression lines produced could be considered parallel [12]. A standard "F" test using analysis of variance techniques which compared the variance between the individual slopes and the variance about the individual lines using the mean squares s_1^2 and s_2^2 respectively, showed the following variance ratio:

$$\frac{s_2^2}{s_1^2}(2,\ 82) = \frac{.776}{.368} = 2.108 < 2.35$$

for an α level of .10. The hypothesis is that the lines are parallel and since $\frac{s_2^2}{s_1^2}$, distributed as $F(2,\ 82)$ where 2 and 82 are the degrees of freedom for s_2^2 and s_1^2, is less than 2.35 it cannot be said that the lines are not parallel. The α level was chosen to be relatively high in order to reduce the chance of making a type II error or to accept the hypothesis when in fact it is false. It was thought to be more advantageous to accept a higher probability of making a type I error or to reject the hypothesis as false when it actually is true [12]. If the lines produced by the transformed equation can be accepted as being parallel under the above conditions, it should be safe to conclude that the actual non-linear regression lines are also parallel, that is the slopes of the lines can be considered equal. This approach was used because there is no satisfactory way to perform an analysis of variance for the non-linear case.

The number of iterations required to estimate the parameters was usually less than 10 and in no case was a computer force off used because the number of programmed iterations had been exceeded. The initial parameters are then used to calculate an estimate of A and B. The new estimate is then used to get a better estimate. This process continues until a satisfactory answer is reached.

An iterative technique for estimating parameters of a non-linear system may or may not work satisfactorily depending on the form of the iterative technique used. The SHARE program used for this research employs the method known as Marquardt's Compromise [13]. This method is a compromise between the linearization (or Taylor Series) and the steepest descent methods [11]. Its chief advantage is that is seems to be applicable to a greater range of problems than the two other methods. Taylor Series may not converge as it is a linear form. Marquardt's Compromise method almost always converges and does not slow down as does the Steepest Descent Method which often converges very slowly and often requires changes in scale. For non-linear problems, no particular method of iteration can be considered best because for a particular problem, modification of any method may result in quicker convergence. A satisfactory answer is one which satisfies the criteria imposed.

Several criteria for stopping are available. When the slope of $\Sigma(Y - \hat{Y})^2$ is near zero; that is, when the partial derivatives approach zero, the criteria are satisfied. In the SHARE program the value of the slope is considered to be near zero when the actual value is less than 0.0001. There are two additional ways in which the SHARE program may be satisfied, when the changes in A and B become too small for an iteration or when any predetermined number of iterations have been made. In this case the standard convergence criteria supplied with the program were used. The Epsilon Test was used to determine convergence [11]. This test is passed whenever

$$\frac{|\delta_j|}{\tau + |b_j|} < \varepsilon \text{ , for all } j \qquad (9)$$

where b_j is the value of the jth parameter

τ is the constant used in convergence test (10^{-3})

ε is the convergence criteria (5×10^{-5})

δ_j is the increment to b_j.

The Epsilon Test is the standard convergence test for this program. The Epsilon Test was achieved for all runs excepting those devoted to single purpose trips (boating, camping, picnicking, swimming) at Raccoon as an intervening park. This disparity is explained by the fact that the counties involved are in the southern part of Indiana, close to the Ohio and Wabash Rivers, and sparsely populated. The road network is poor in comparison to the road network in other parts of the State of Indiana. As a result, very few trips were observed and some counties showed no trips at all irregardless of the distances which were usually greater than 50 miles. The samples did not fit the model and these runs were not used in the analysis. The use of Cagles Mill as an intervening park produced estimates for all single purpose trips.

The program produced 10 sets of parameters, A and B, for use in the equation $Y = Ae^{-Bx}$. The equations developed are to be used to predict trip rates for the total trips, boating, swimming, picnicking, and camping trips for both cases. The 1965 data for Raccoon and Cagles Mill were used as well as the 1966 data for Cagles Mill. The values were averaged for each category and the average values of A and B were used to produce straight line plots on a semi-logarithmic graph for estimating purposes (see Figures 3 and 4).

Using the estimating lines for trips to the closest park and intervening park, one is able to produce over 95 percent of the total trips to Raccoon for 1965 and to Cagles Mill for 1965 and 1966. This estimate (95 percent) is considered to be entirely adequate for future planning purposes.

Standard statistical tests such as Simultaneous Significance Tests for Multiple Contrasts in the Analysis of Variance were run on the trips to the parks for the various trip purposes (14). The trips were converted to percentages in order to account for the difference in total observed trips which resulted from the differences in the number of observation days as well as the differences in the annual attendance at each park. Of interest in these tests was whether or not there was any significant differences for the various trips due either to parks or to years.

These tests showed that there existed no significant difference between Raccoon and Cagles Mill for the purpose of boating, picnicking, and swimming. From this is inferred that the attraction of each park is the same and the only difference in trips arriving at each park can be attributed to the population distribution around each park. More of the population is closer to Raccoon than to Cagles Mill and more trips are made to Raccoon than to Cagles Mill. The fact that the estimating line for total trips to the closest park has a higher Y intercept (338.4 versus 129.3) than the line for total trips to a park with an intervening park, validates the assumption that a recreational trip desires to be as short as possible.

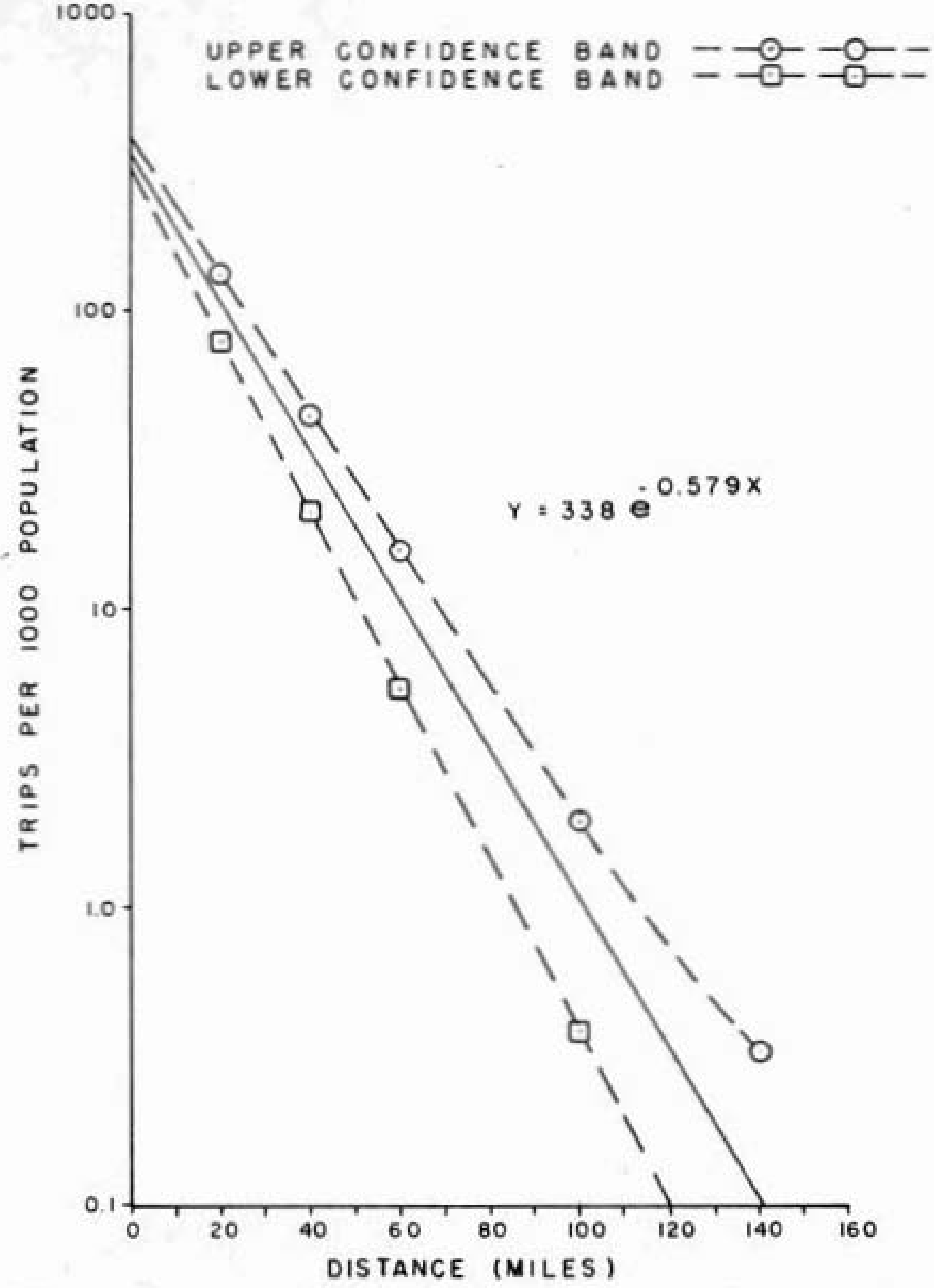

FIGURE 3
TOTAL TRIPS TO CLOSEST PARK

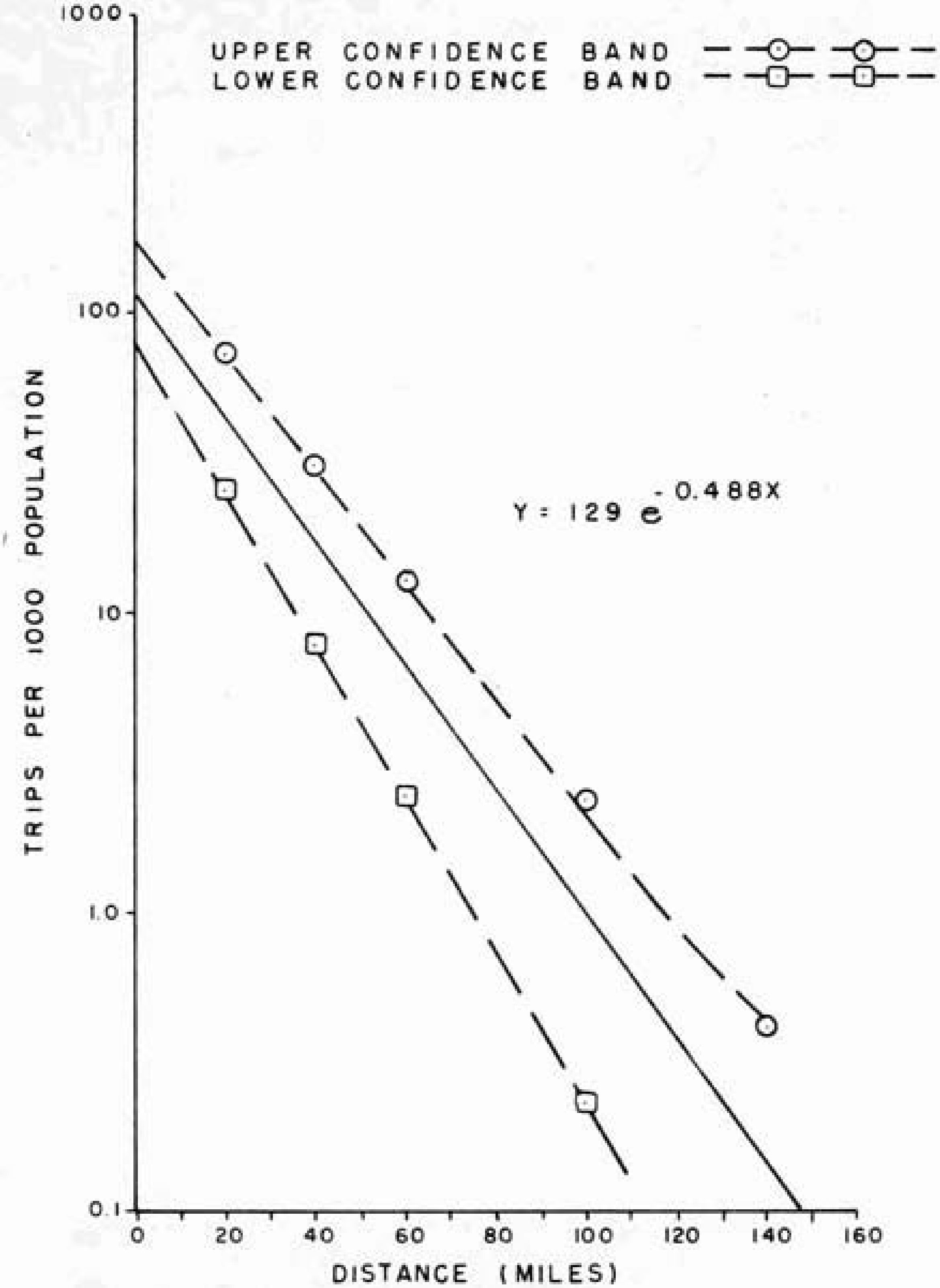

FIGURE 4
TOTAL TRIPS WITH INTERVENING PARK

For the two primary curves (Figures 3 and 4), Confidence Intervals were computed by determining the lines for the average values of the upper and the lower confidence bands as determined by the standard convergence criteria. The lines appear to diverge as X increases, but actually the confidence interval decreases as X increases. The largest value of the confidence band occurs when X is zero. This is due apparently to the fact that fewer observations are available for the smaller values of X than are available for the larger values of X. In other words, fewer counties are closer to the parks than are farther from the parks, using 50 miles as a division point.

There is no generally accepted theory for estimation of confidence regions for non-linear parameters. When a regression function is not linear in the parameters, two general procedures are available for determining confidence intervals. In one, the assumption is made that the function is approximately linear in the vicinity of the optimum value of the parameter, which is A or B. Approximate confidence bands are then derived for the individual parameters, or an exact confidence region may be derived for both parameters. The other method gives an exact confidence interval but requires that the function be expressed in a particular form.

In the SHARE Program, the procedure for obtaining approximate information takes into account the non-linearity of the model. The confidence region for a parameter is valid only in the vicinity of the least squares point; outside of this region, the confidence bands may or may not break down.

At the least squares point, the estimated error variance is:

$$se^2 = \hat{\Phi}/(n - k)$$

with $(n - k)$ degrees of freedom and where $\hat{\Phi}$ is the estimated sum of squares of the residuals, n is the number of data points, and k is two, the number of parameters.

If the assumption that the form of the non-linear model is correct, the deviations of the parameter estimates (A and B) from their true values are due to the random error in the data. The variance ratio is distributed approximately as the F statistic:

$$\frac{(\bar{\Phi} - \hat{\Phi})/k}{\hat{\Phi}/(n - k)} = F_{(1 - \alpha)}(k, n - k) \qquad (10)$$

where Φ is the sum of squares of the residual and $F(1 - \alpha)$ is the value from the F statistic tables. In the SHARE Program, a value of 4.0 is used.

The procedure is to choose a confidence probability $(1 - \alpha)$ and by using equation 10, to determine the critical value of Φ. After the critical value of Φ has been established, all parameters are then varied one at a time by trial and error techniques to determine upper and lower confidence limits for the values of each parameter [11]. The critical value of Φ is printed as output along with the non-linear confidence values for each parameter.

Trips by Purpose

In order to determine what percentage of the total trips each trip purpose produces, two tables were developed. The first (Table 3) shows the percentage of total trips contributed by each single purpose, no

TABLE 3

SINGLE PURPOSE TRIPS IN PERCENT OF TOTAL ANNUAL TRIPS

	Raccoon 1965	Cagles Mill 1965	Cagles Mill 1966
Boating	11.1	9.6	18.2
Camping	3.2	4.8	5.1
Picnicking	6.5	5.7	6.5
Swimming	12.3	12.4	15.2

TABLE 4

MULTI-PURPOSE TRIPS IN PERCENT OF TOTAL ANNUAL TRIPS

	Raccoon 1965	Cagles Mill 1965	Cagles Mill 1966
Boating	36.9	37.6	47.1
Camping	18.4	25.7	13.4
Picnicking	32.3	36.4	21.6
Swimming	38.1	55.6	31.9

multi-purpose trips are included. The second table (Table 4) is considered to be more useful in explaining the trip purposes because it contains the multi-purpose trips as well as the single purpose trips for each purpose.

One conclusion that can be made is that swimming is the most preferred activity; followed in order by boating, picnicking, and camping. (See Table 5.)

Arrival distributions were plotted in order to determine the arrival patterns both for total trips and for each trip purpose. Considerable variation exists among the days of the weekend, Friday, Saturday, and Sunday (see Figures 5, 6, and 7). The only major difference between parks was noted in the magnitude of trips per hour. This effect however, has already be explained as being due to the population distribution around the parks.

Saturday and Sunday arrivals show variations primarily in the number of arrivals, not in the distribution of arrivals (see Figures 8, 9, and 10). Friday arrivals show a distinctly different pattern (see Figures 8, 9, and 10). This results from a greater proportion of Friday arrivals being campers who intend to stay all weekend (see Figures 11, 12, and 13). Saturday and Sunday arrivals are primarily for one day visits. The late hour arrivals for Friday are perhaps explained by reasoning that the trips begin only after the completion of the Friday work day hours.

The values for the arrival distributions were obtained by averaging the summer weekend observations for the months of June, July, and August. From Figure 14, it can be seen that less than 30 percent of the total annual trips to a park are made prior to June. By the end of August, more than 90 percent of the total annual trips have been made. The

TABLE 5

TRIP PURPOSE IN PERCENT OF TOTAL ANNUAL TRIPS, AVERAGED FOR ALL PARKS

Boating	40.0
Camping	19.9
Picnicking	30.0
Swimming	42.0

TABLE 6

AVERAGE TRIP PURPOSE IN PERCENT FOR SUMMER MONTHS (JUNE, JULY, AUGUST)

	Raccoon 1965	Cagles Mill 1965	Cagles Mill 1966
Boating	36.0	36.0	33.0
Camping	18.6	21.0	16.0
Picnicking	32.0	33.3	25.5
Swimming	42.0	55.1	45.5

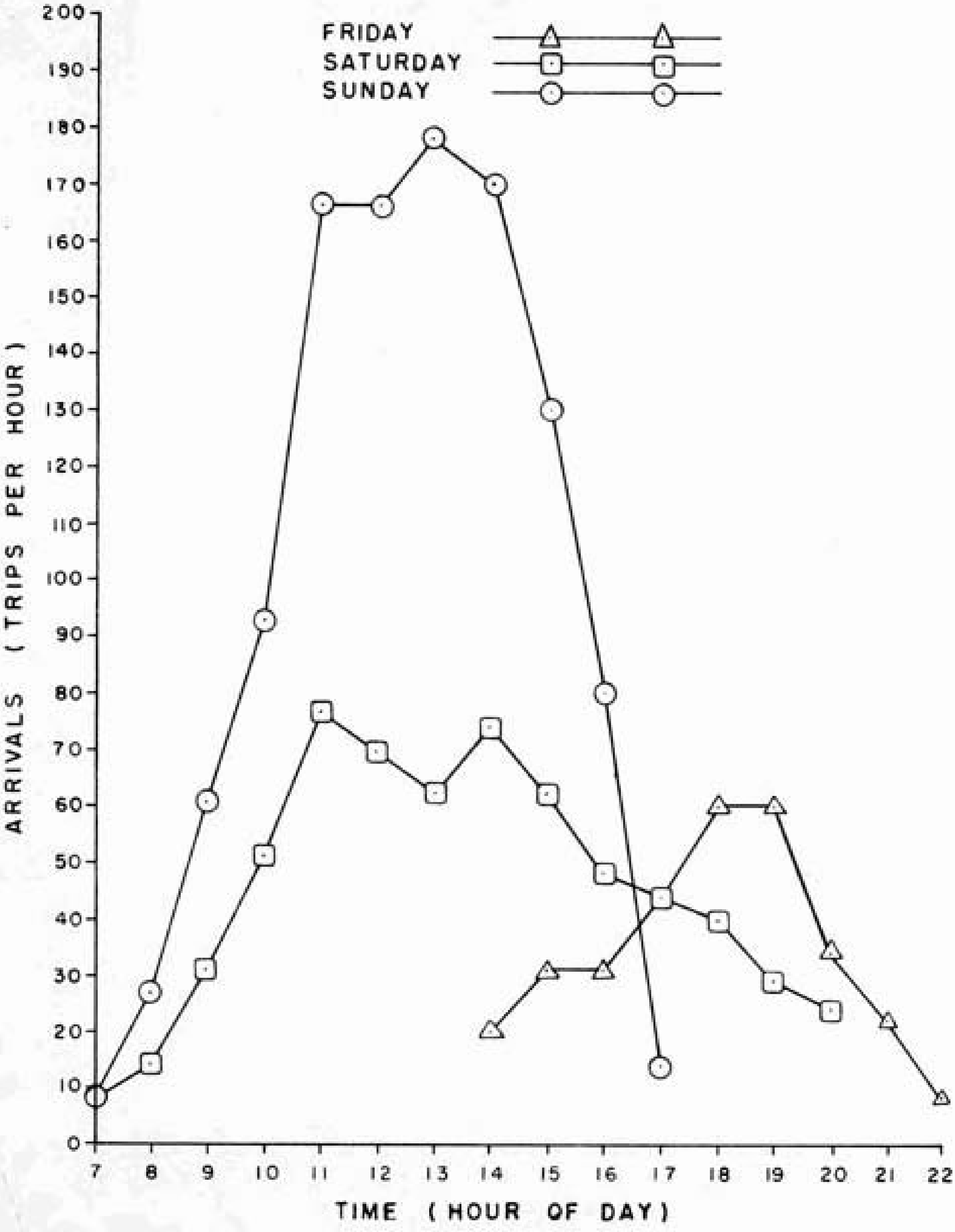

FIGURE 5
TOTAL TRIP ARRIVALS TO RACCOON IN 1965

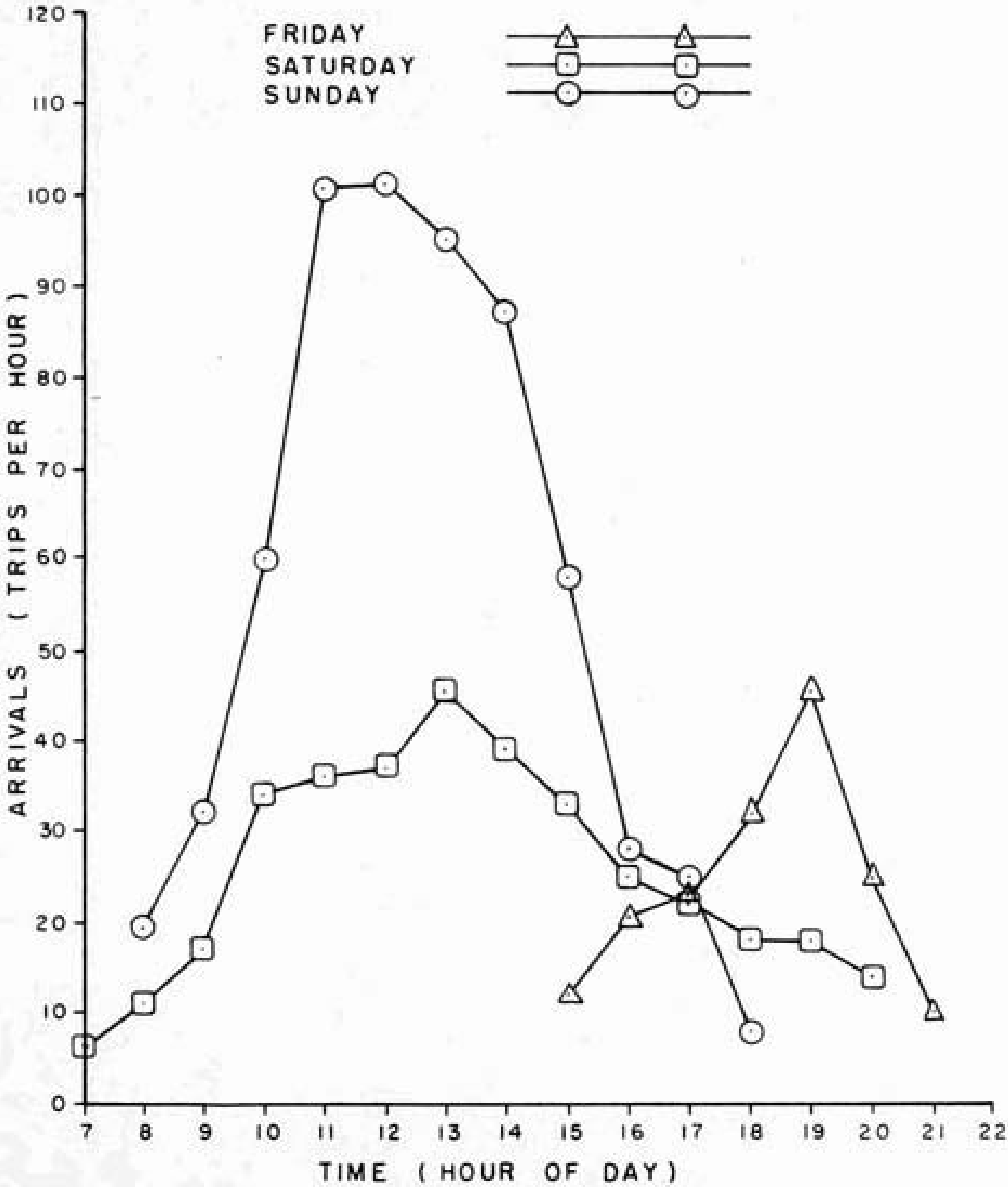

FIGURE 6
TOTAL TRIP ARRIVALS TO CAGLES MILL IN 1965

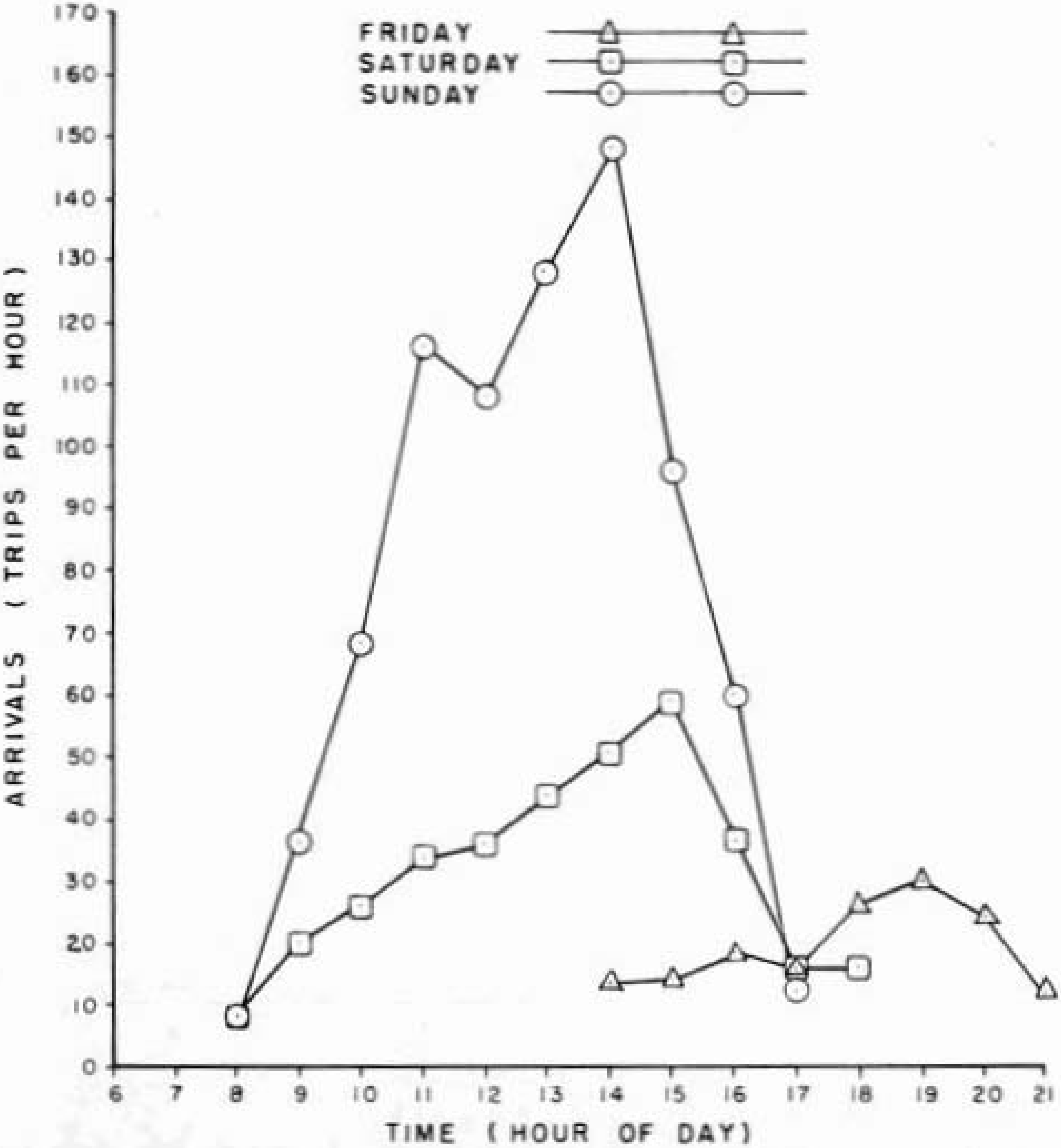

FIGURE 7

TOTAL TRIP ARRIVALS TO CAGLES MILL IN 1966

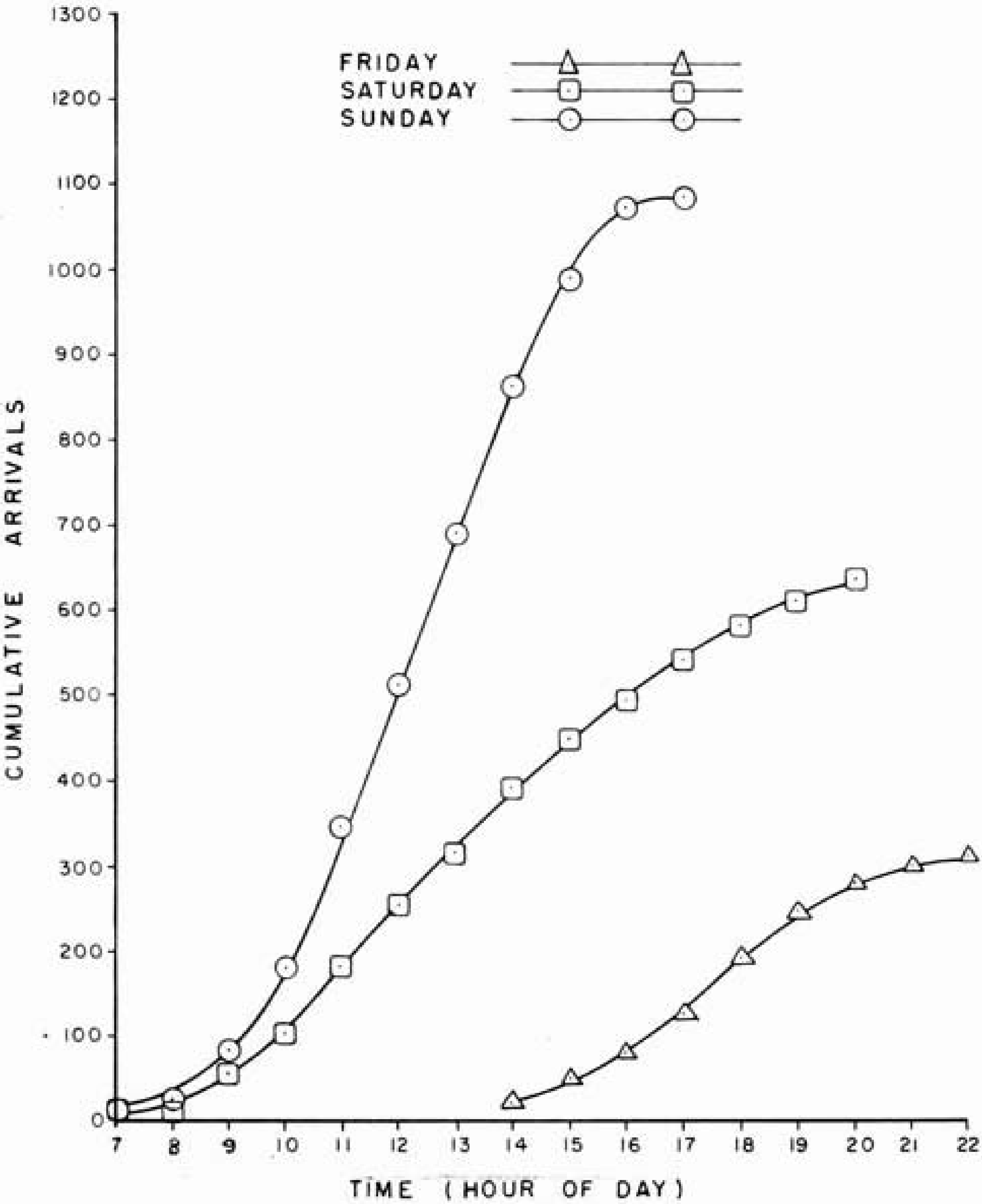

FIGURE 8

AVERAGE TOTAL CUMULATIVE ARRIVALS TO RACCOON IN 1965

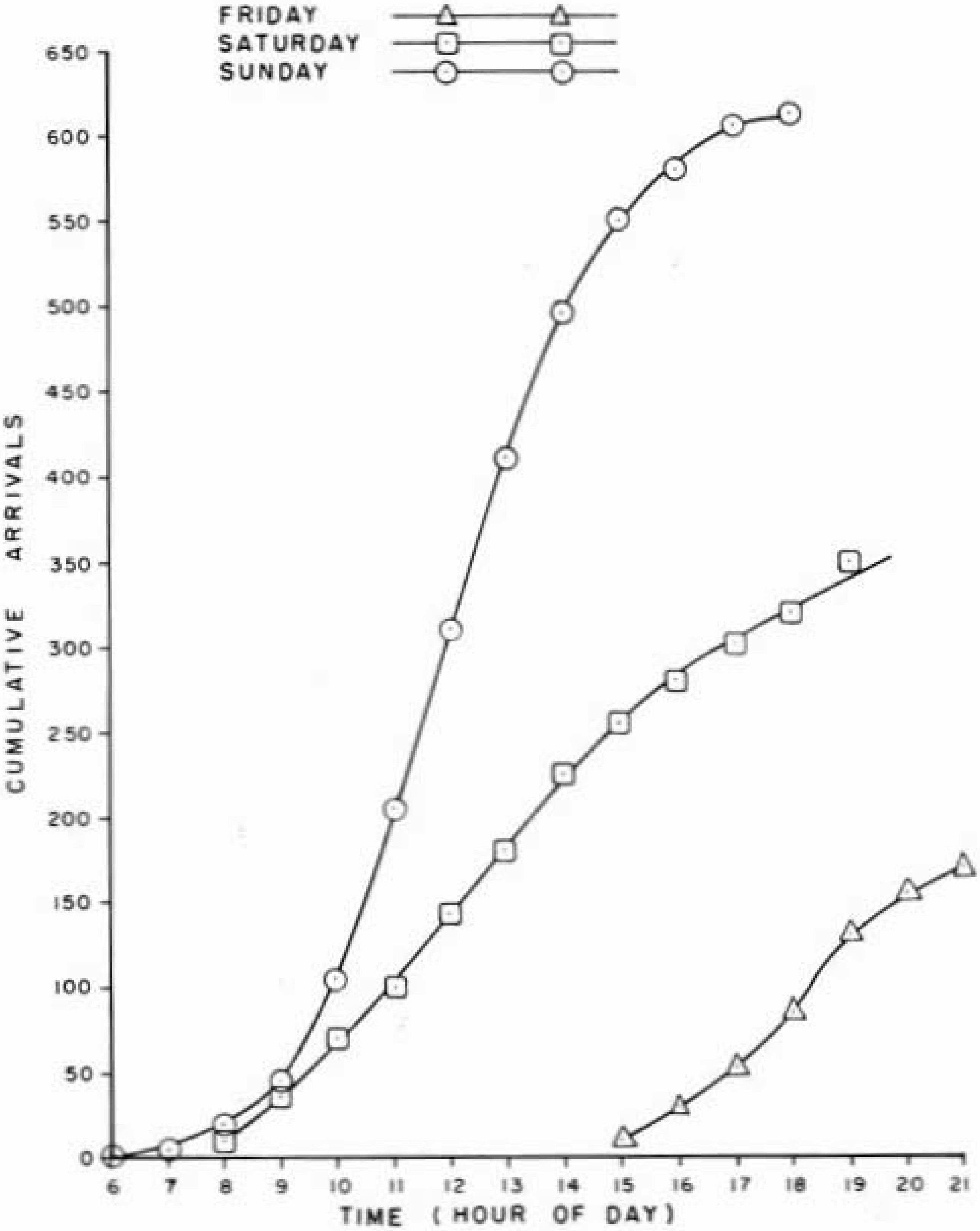

FIGURE 9
AVERAGE TOTAL CUMULATIVE ARRIVALS TO CAGLES MILL IN 1965

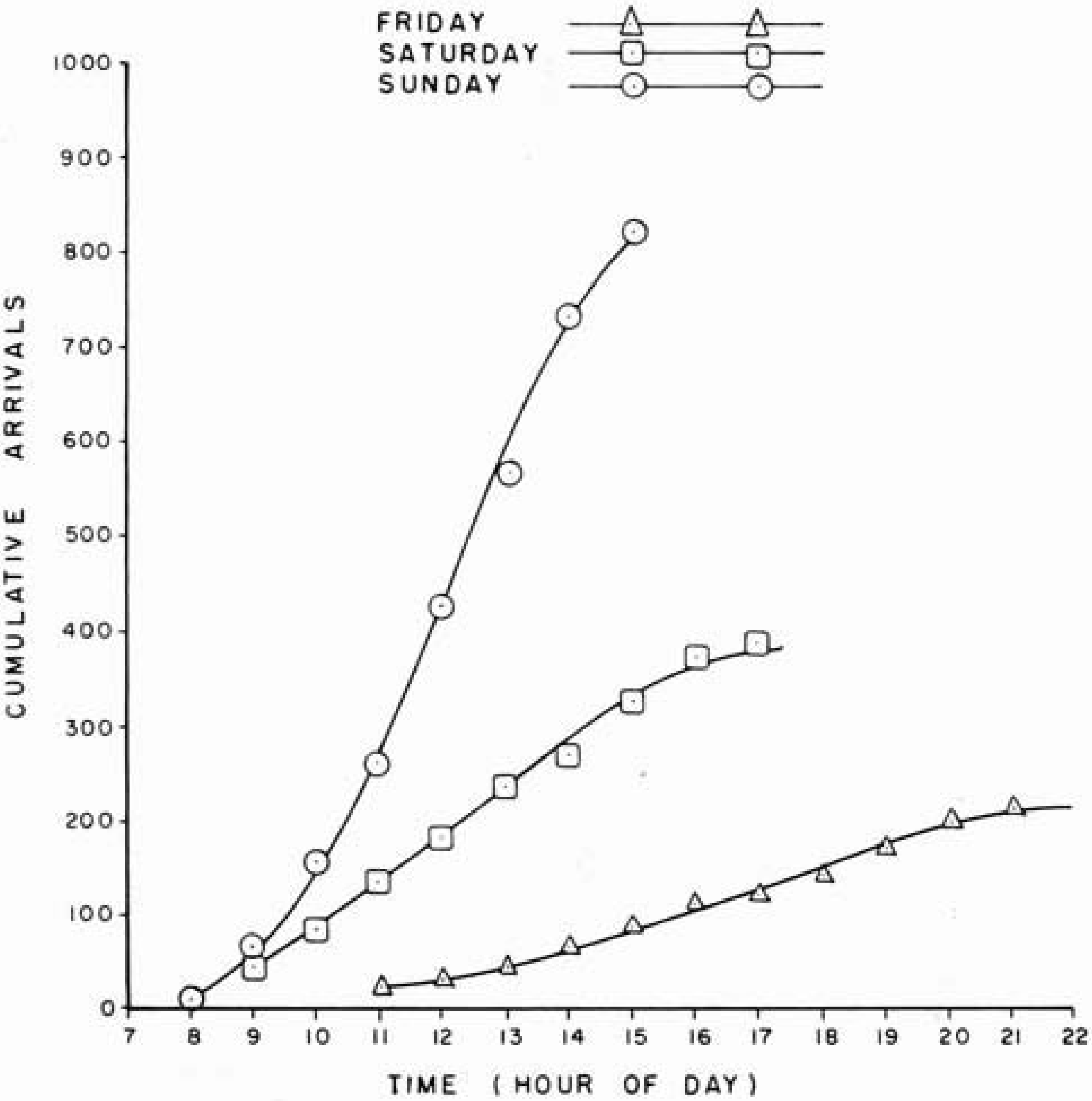

FIGURE 10

AVERAGE TOTAL CUMULATIVE ARRIVALS TO CAGLES MILL IN 1966

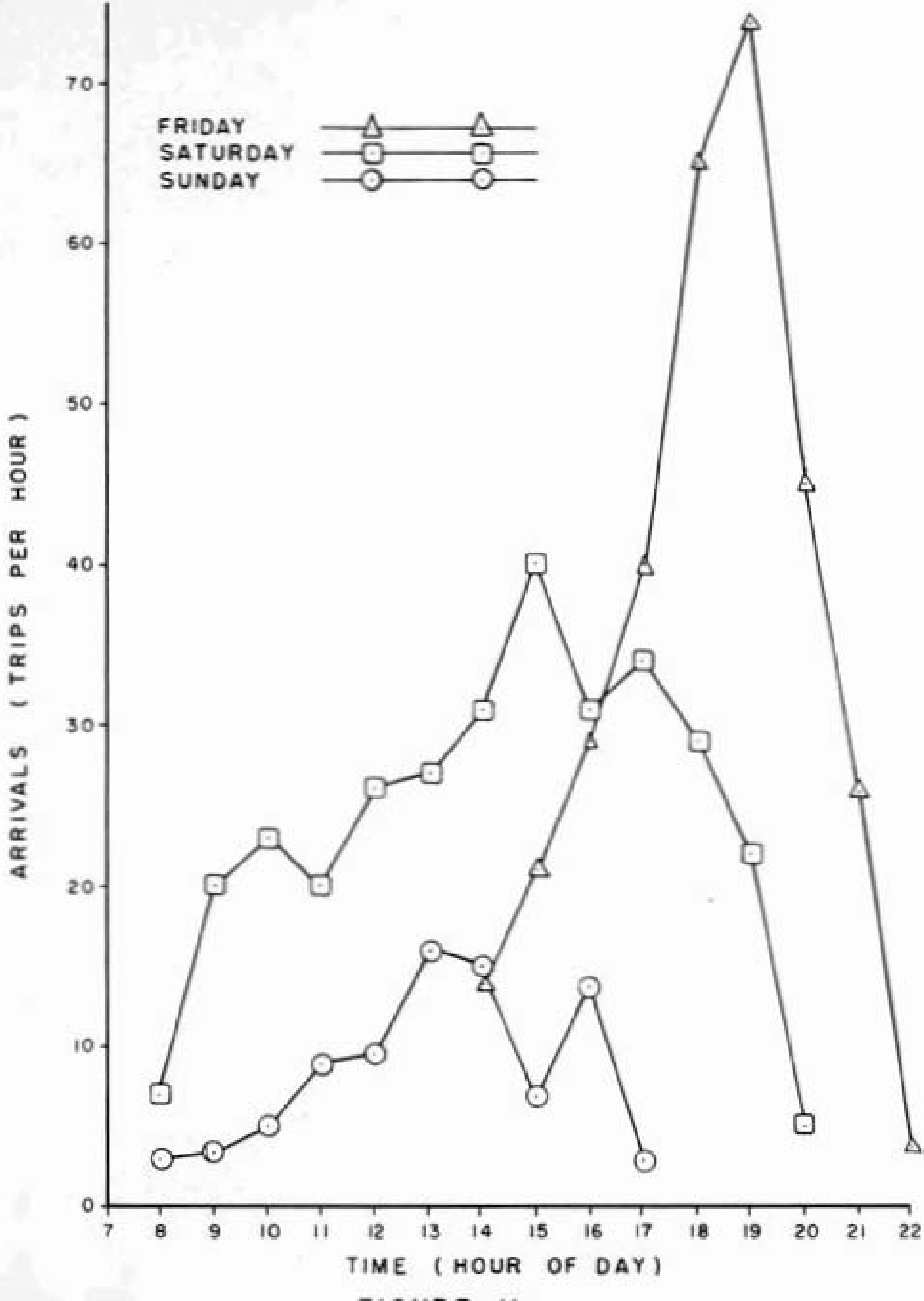

FIGURE II

CAMPING ARRIVALS – RACCOON 1965

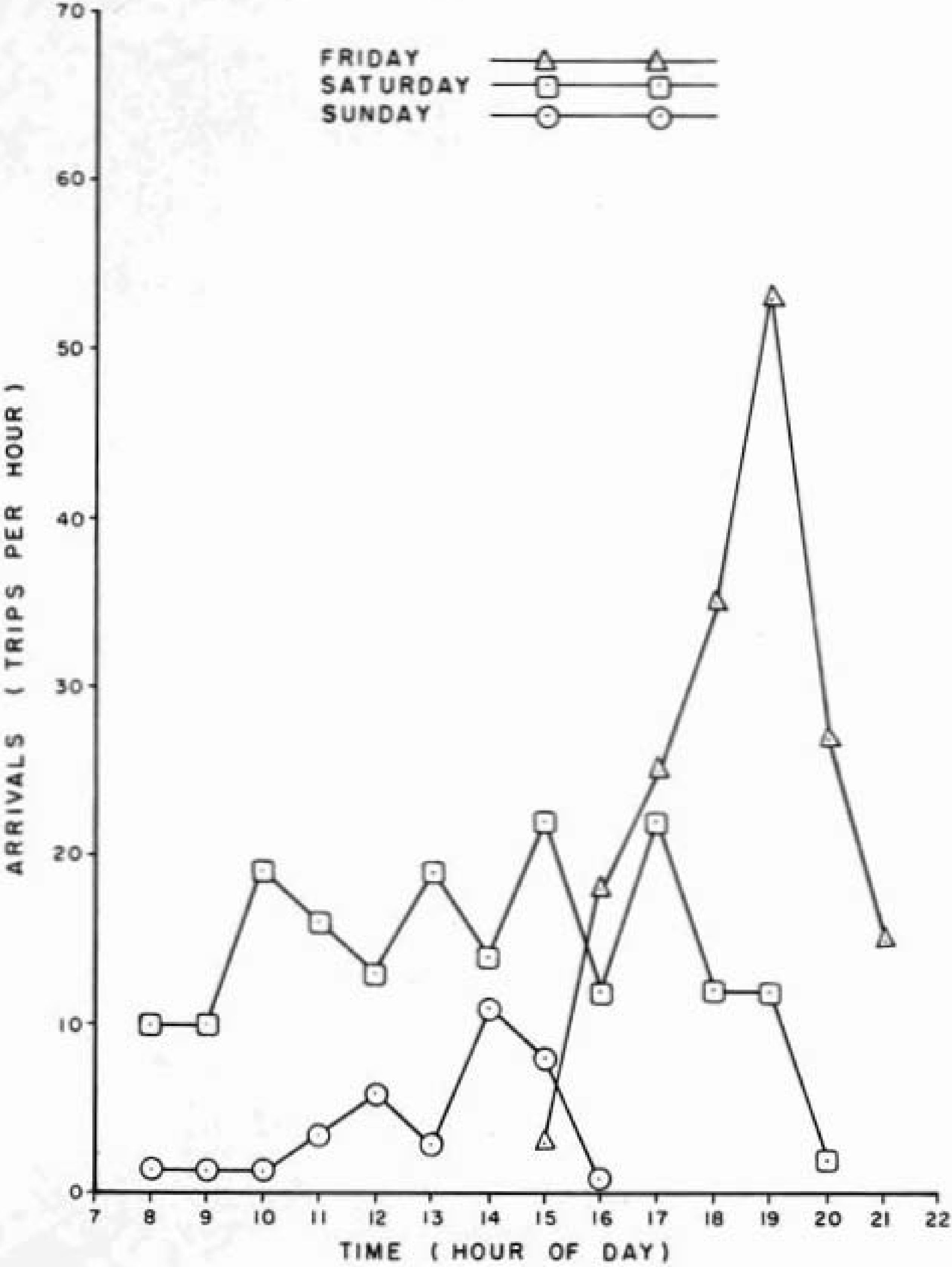

FIGURE 12

CAMPING ARRIVALS — CAGLES MILL 1965

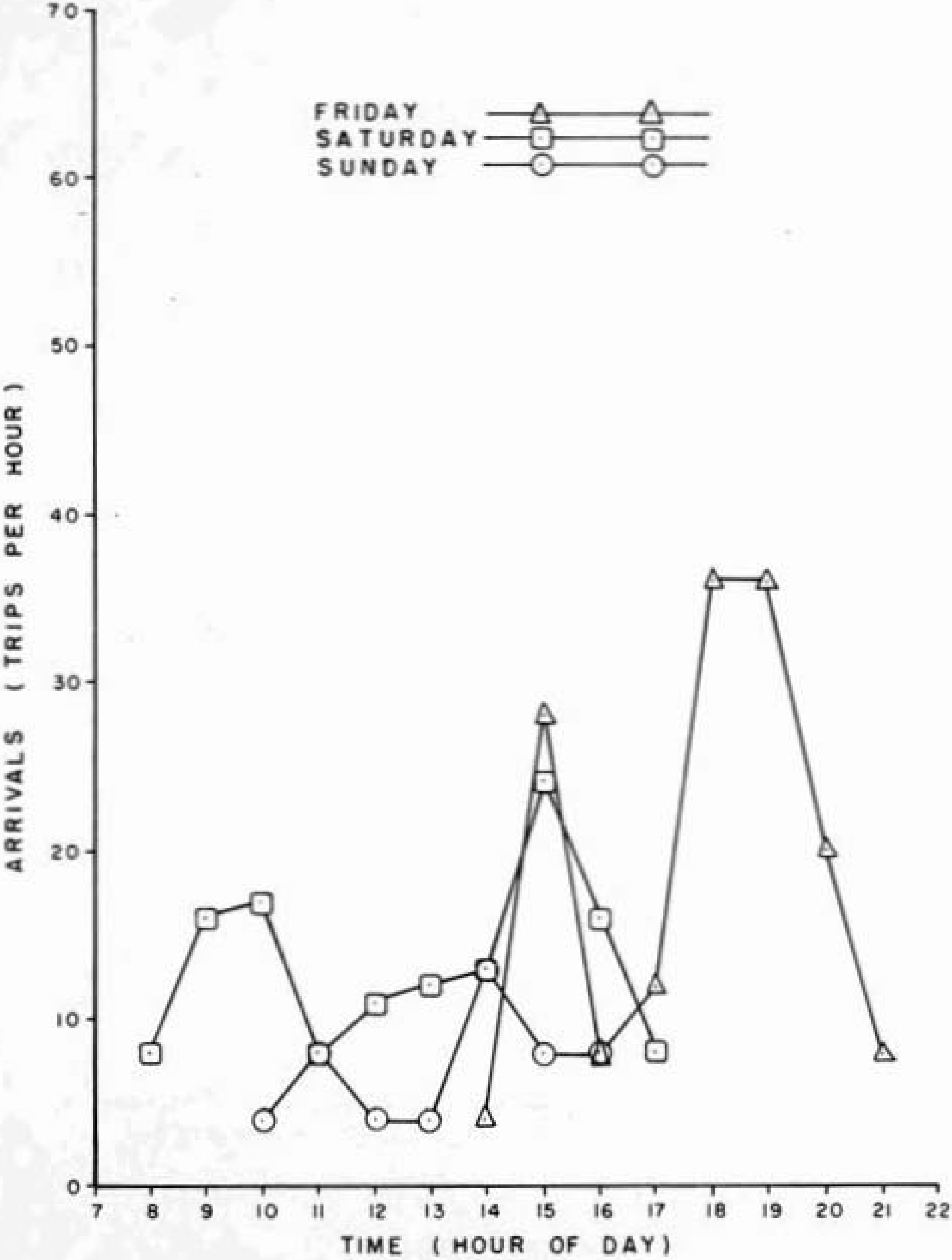

FIGURE 13

CAMPING ARRIVALS — CAGLES MILL 1966

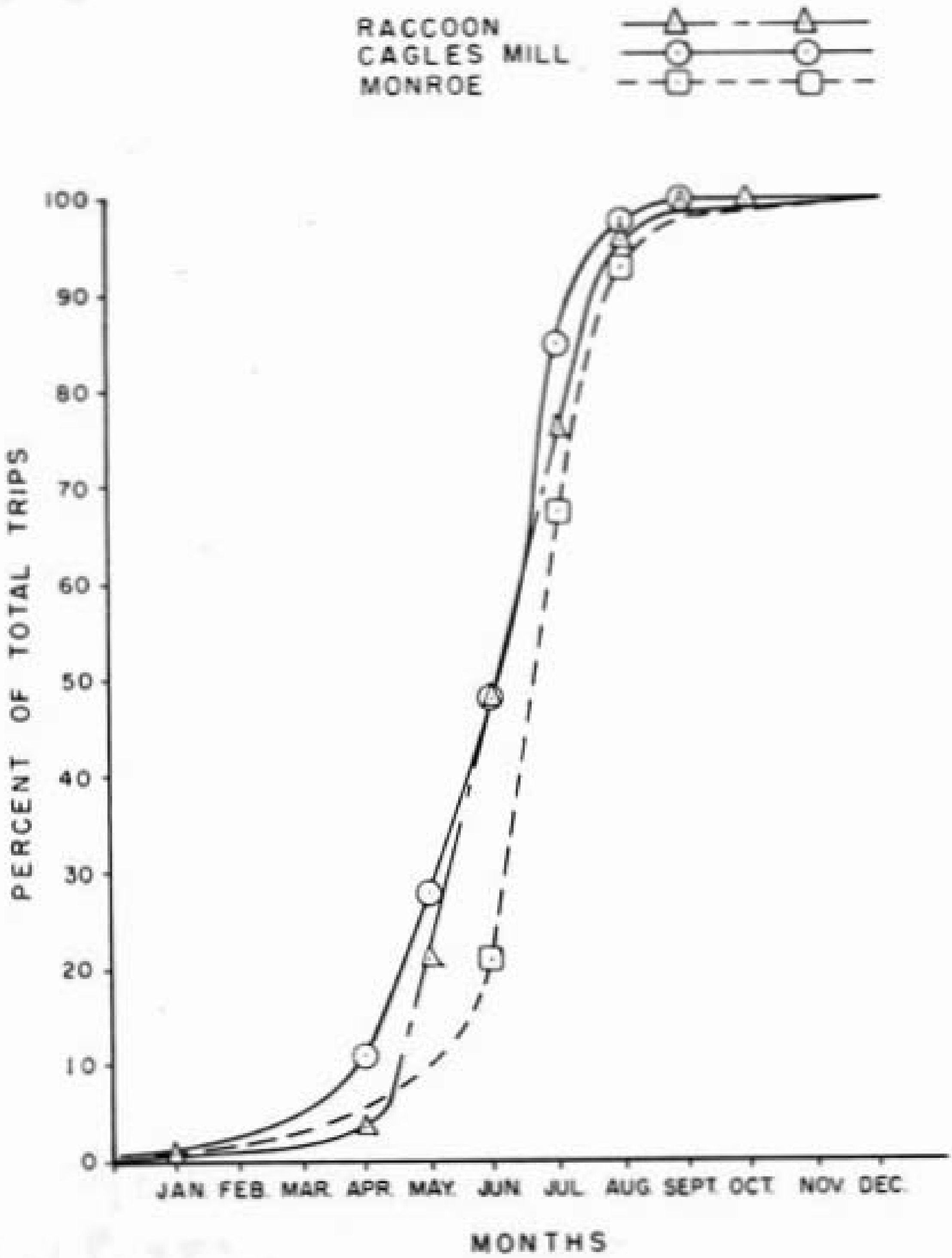

FIGURE 14

CUMULATIVE TRIPS

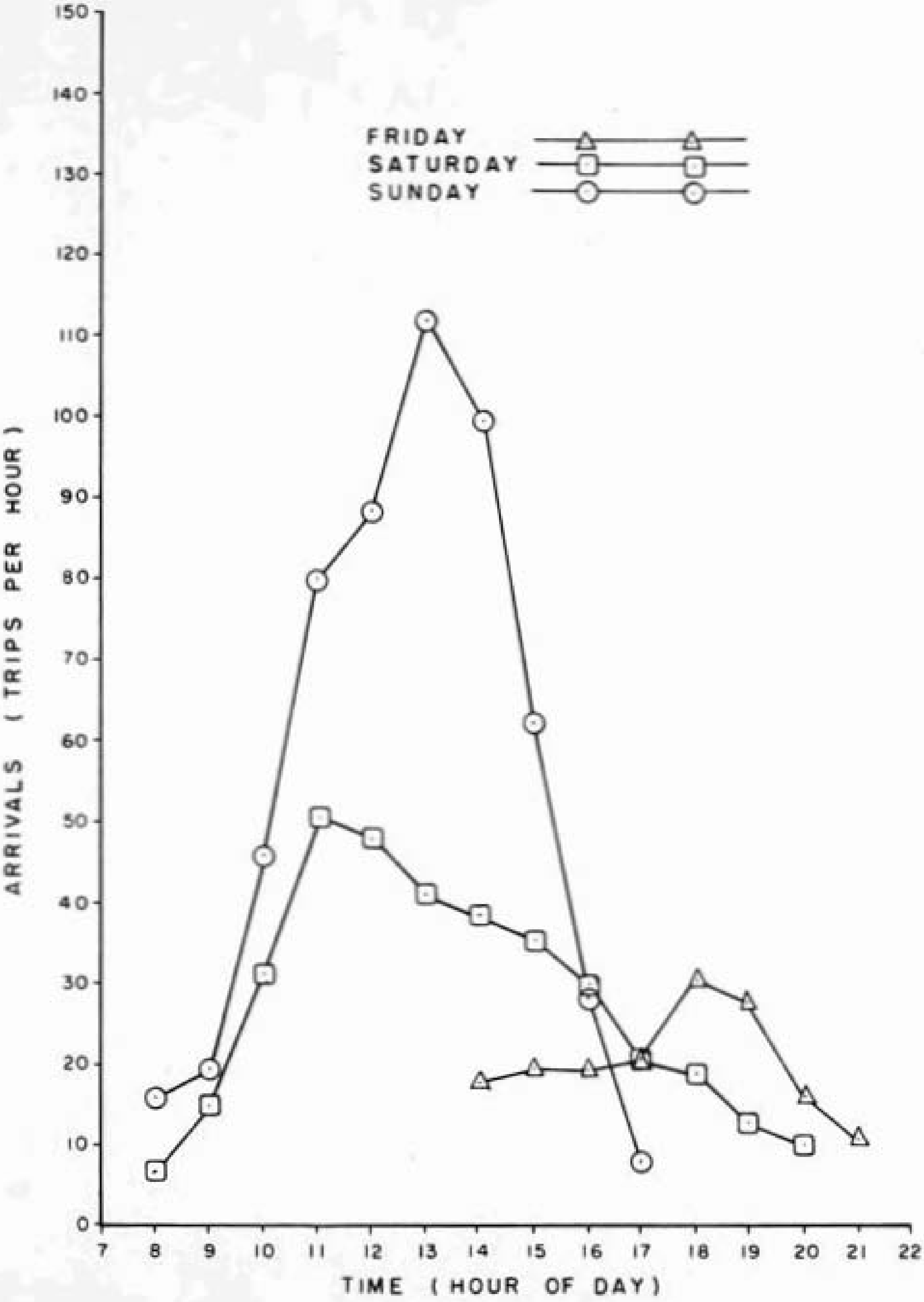

FIGURE 15

SWIMMING ARRIVALS – RACCOON 1965

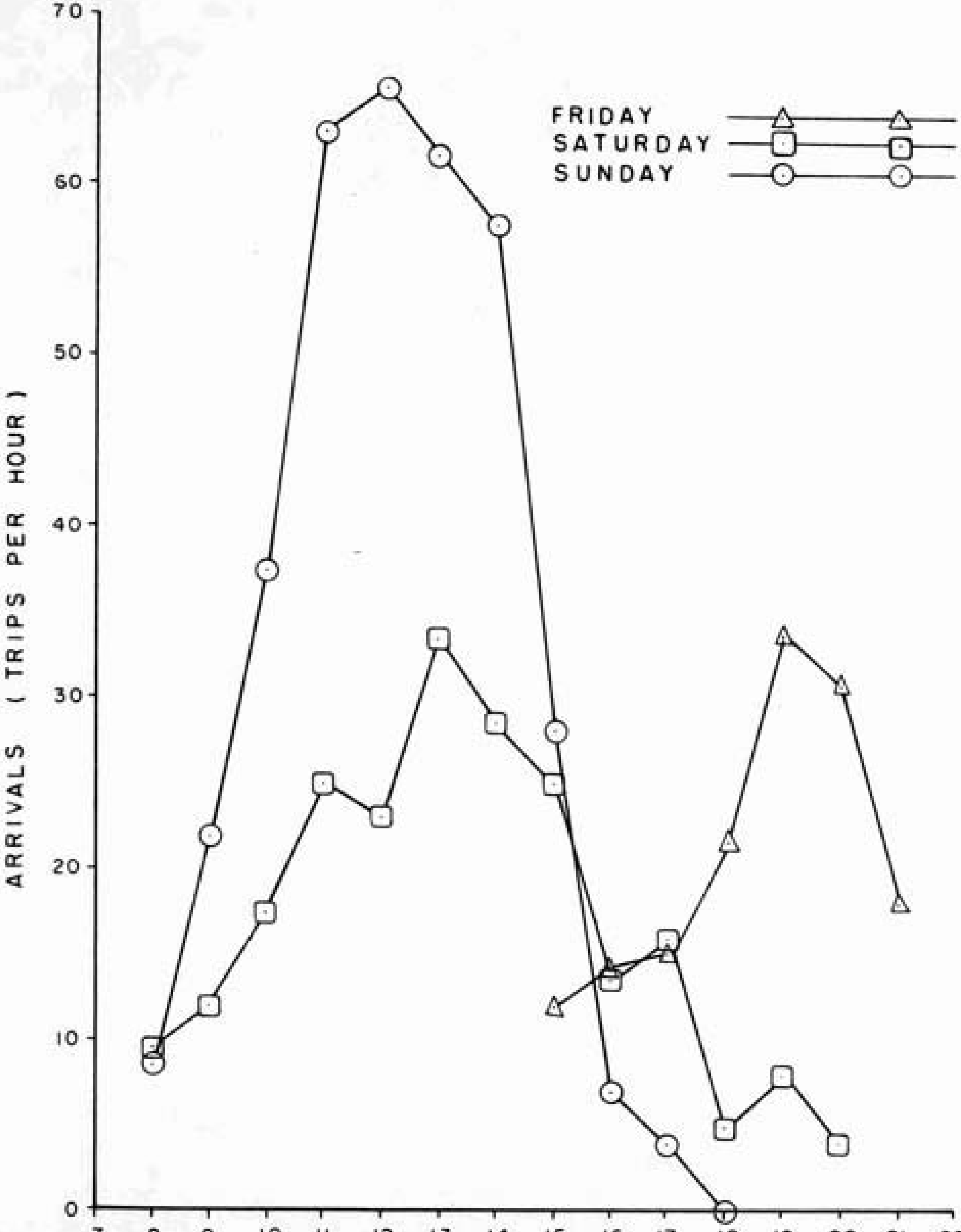

FIGURE 16

SWIMMING ARRIVALS — CAGLES MILL 1965

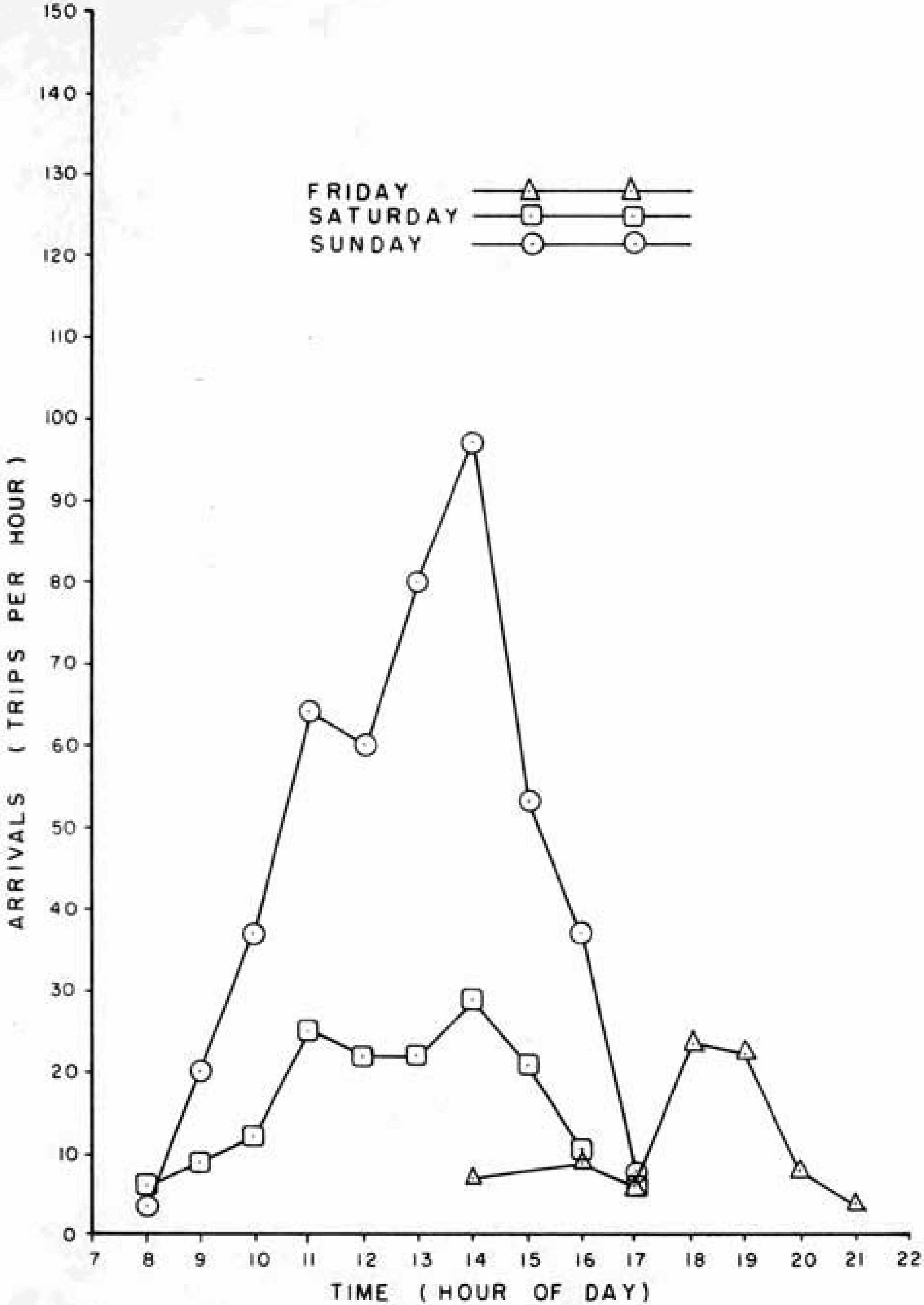

FIGURE 17

SWIMMING ARRIVALS — CAGLES MILL 1966

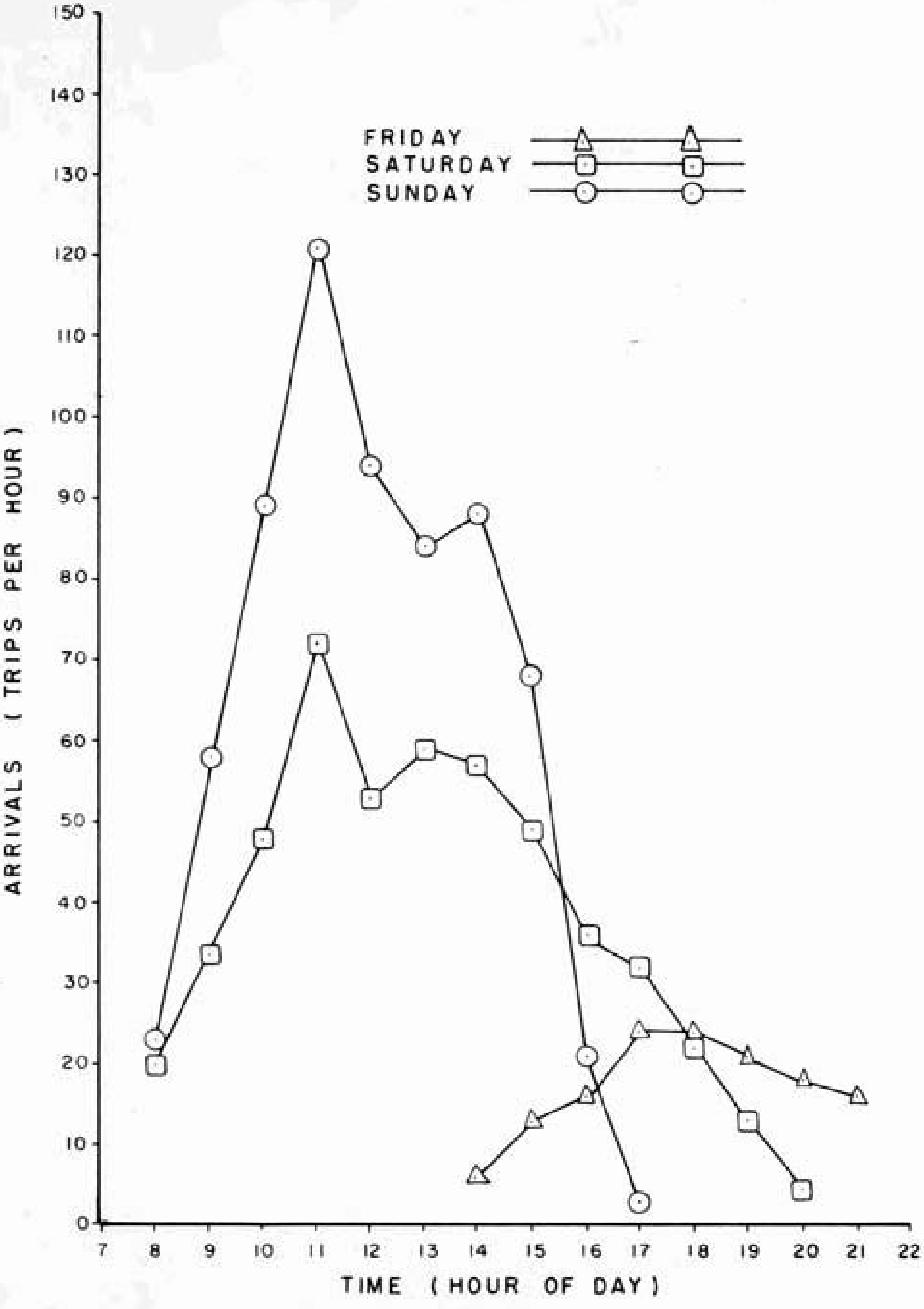

FIGURE 18

BOATING ARRIVALS — RACCOON 1965

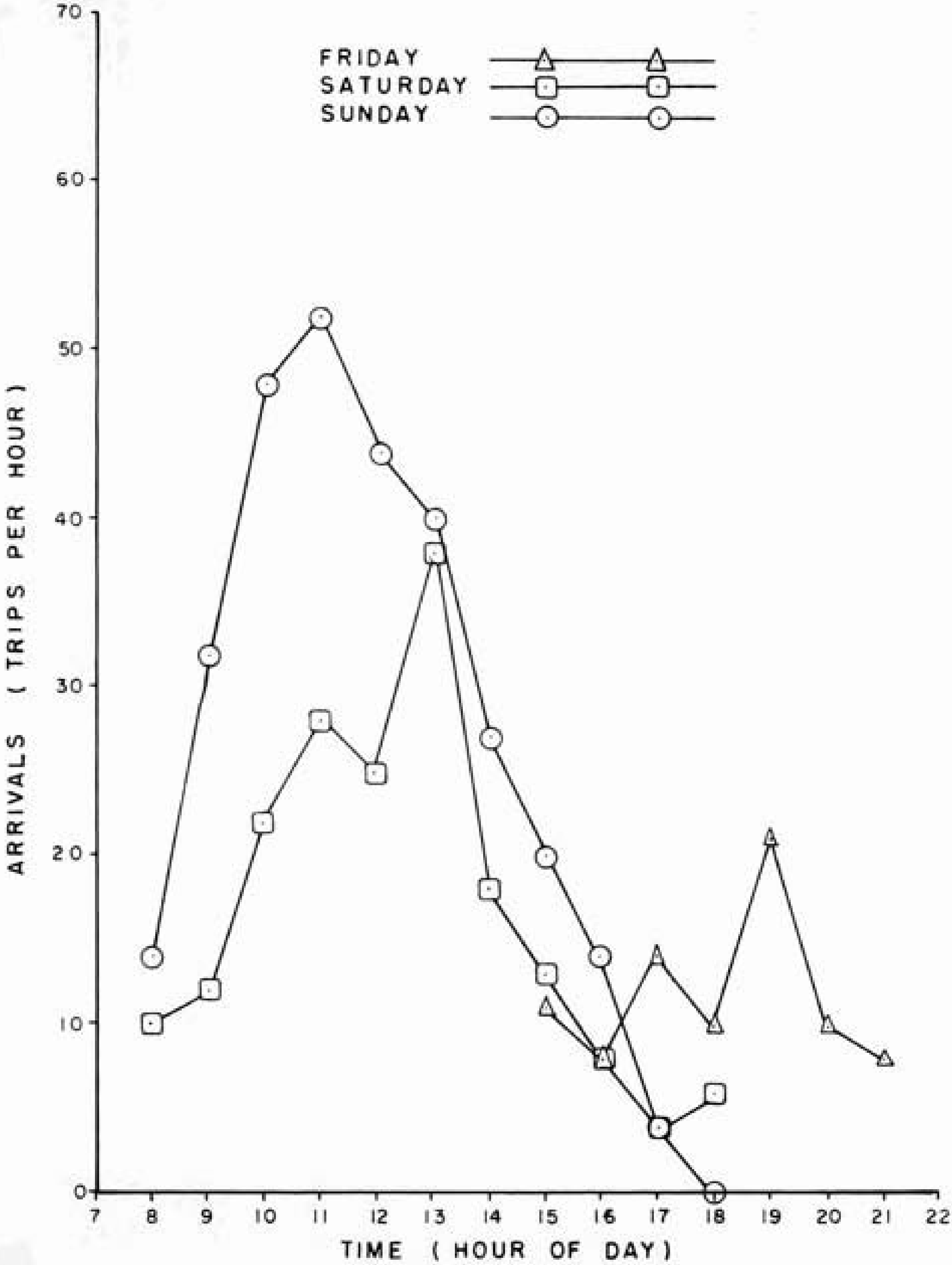

FIGURE 19

BOATING ARRIVALS — CAGLES MILL 1965

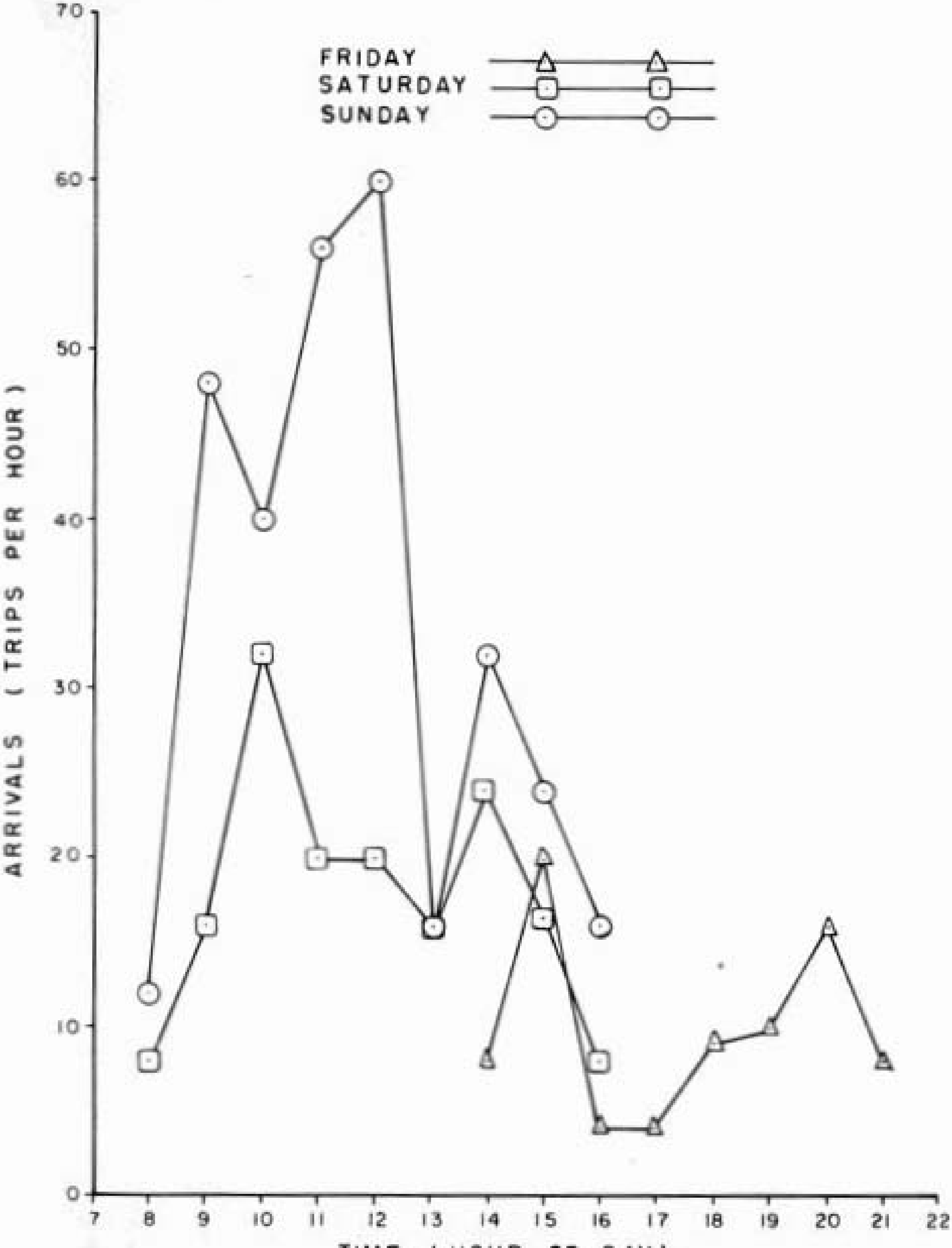

FIGURE 20

BOATING ARRIVALS — CAGLES MILL 1966

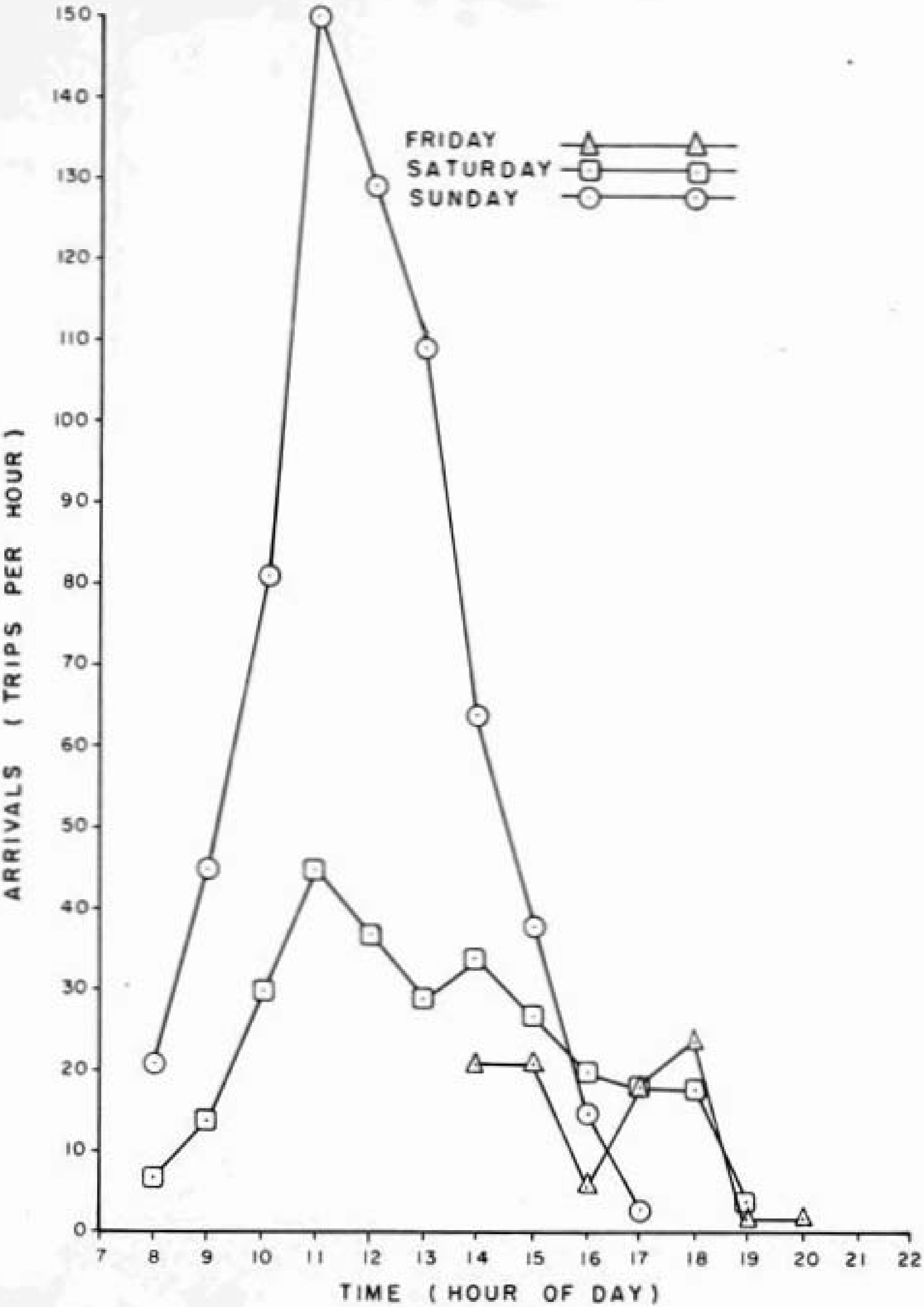

FIGURE 21

PICNICKING ARRIVALS — RACCOON 1965

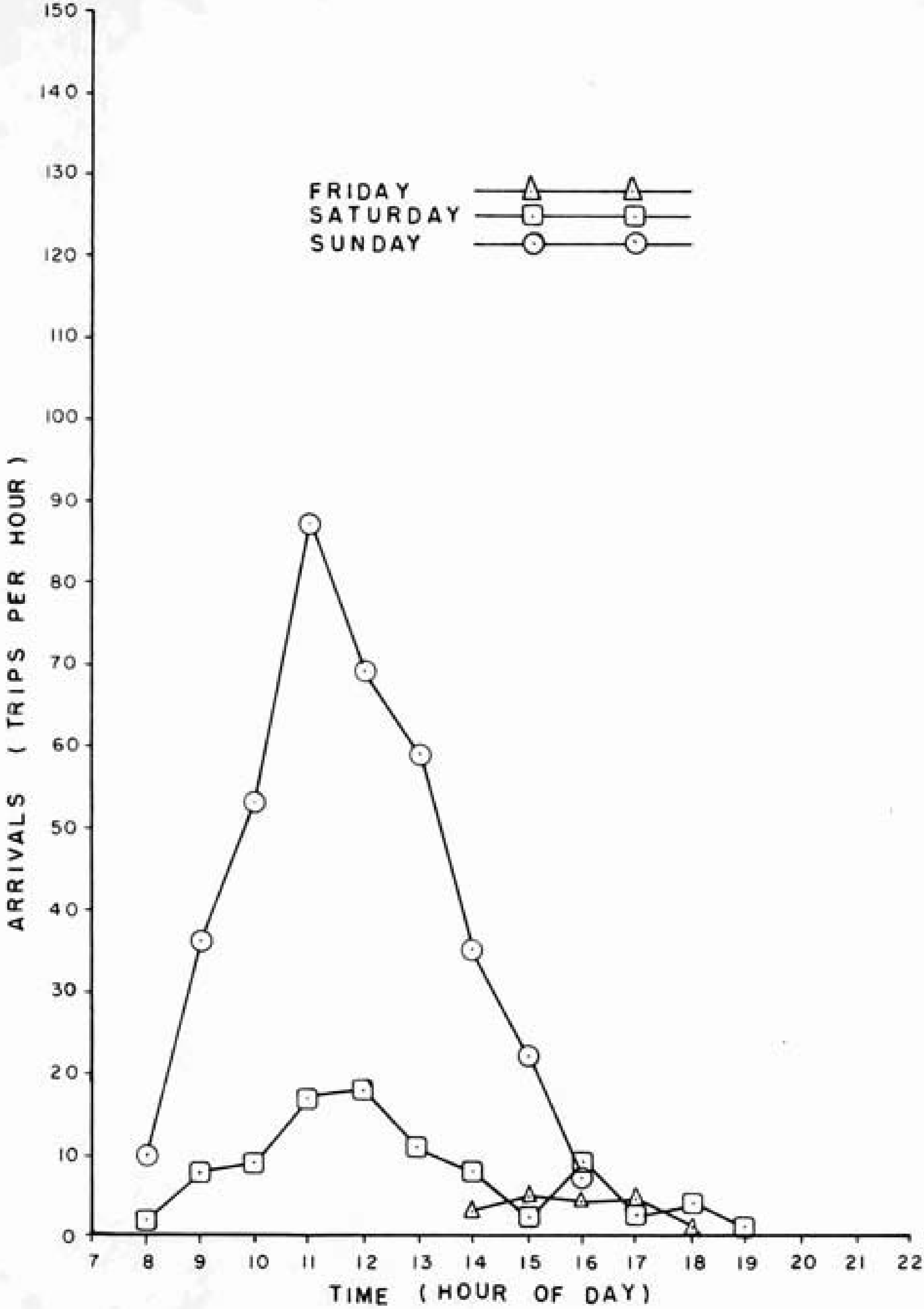

FIGURE 22

PICNICKING ARRIVALS — CAGLES MILL, 1965

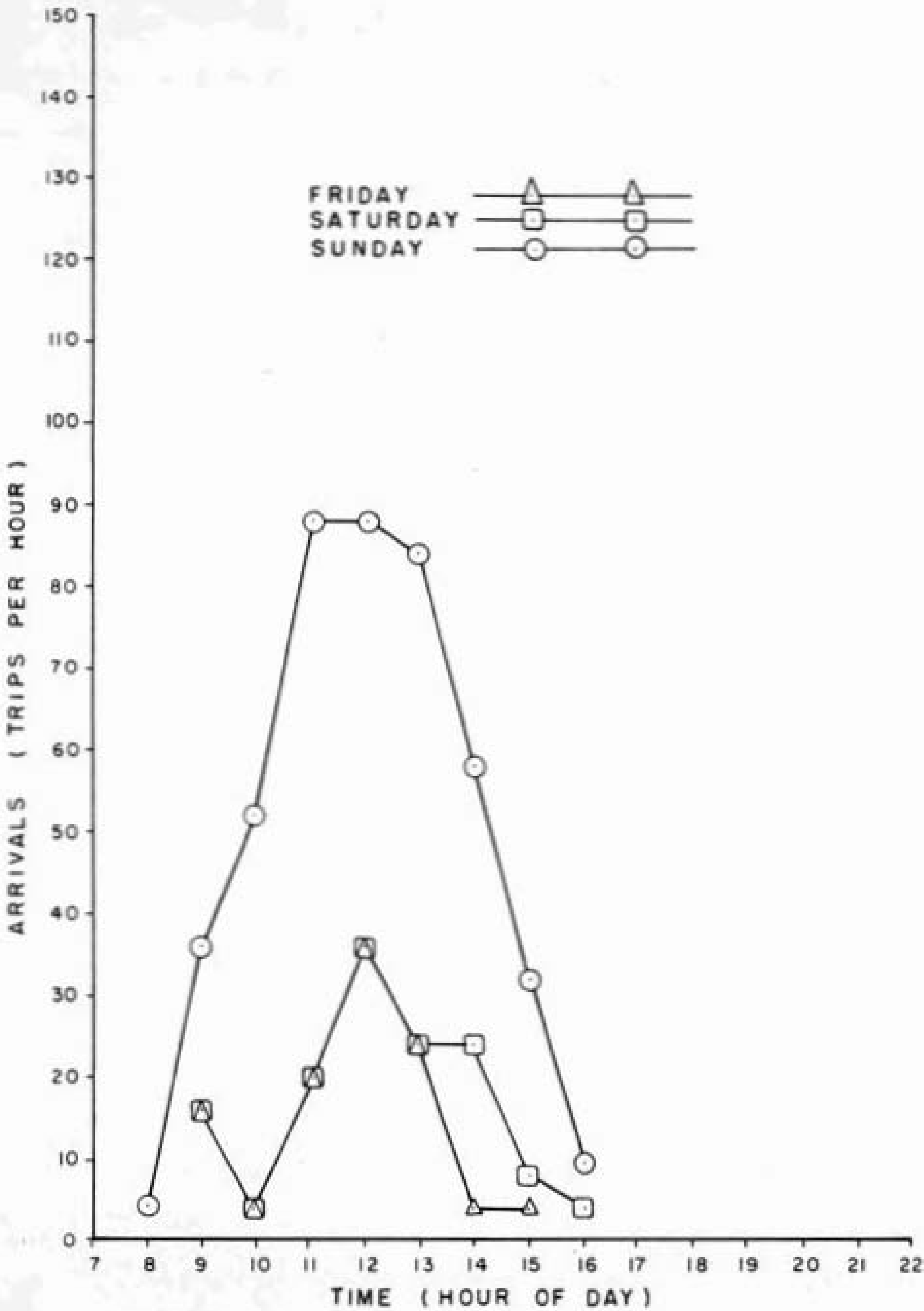

FIGURE 23

PICNICKING ARRIVALS — CAGLES MILL 1966

arrival rate for the months other than June, July, and August will be much less than those plotted in the figures. These figures may be used as the average arrival rates and daily distributions for the parks involved.

The maximum number of trips observed in one day was a Sunday when 1348 trips were sampled at Raccoon State Recreation Area.

Figure 24 shows the trip rates by purpose. The values were determined in the same manner as were the values for total trips. The plots show the relative attractiveness of each activity.

Of interest is the relationship of the curves to each other in terms of distance. For distances of less than 30 miles, swimming as a trip producer is ahead of all the others; beyond 30 miles, boating becomes more attractive than swimming; beyond 45 miles, picnicking is the most attractive; and camping is the most attractive beyond 70 miles. The curves for boating, picnicking, and camping tend to converge with an increase in distance which indicates that as the distance increases the trip purpose has less effect on the trip rate. It may also indicate that more multi-purpose trips are made for longer distances than for shorter distances.

The curve for swimming reflects the fact that swimming, as a separate activity, can be satisfied closer to home than can most other activities. Also, the high rate for short distances reflects the desire of many people for a short duration trip for a swim. This can also be inferred from the arrival distributions which show the swimming arrivals to be later in the day. The 1966 data was not used because of the lack of swimming at Raccoon. It is felt that the swimming rate at Cagles Mill would also be affected since the two parks are not very far apart. Some of the trips that normally would have gone to Raccoon went instead to Cagles Mill.

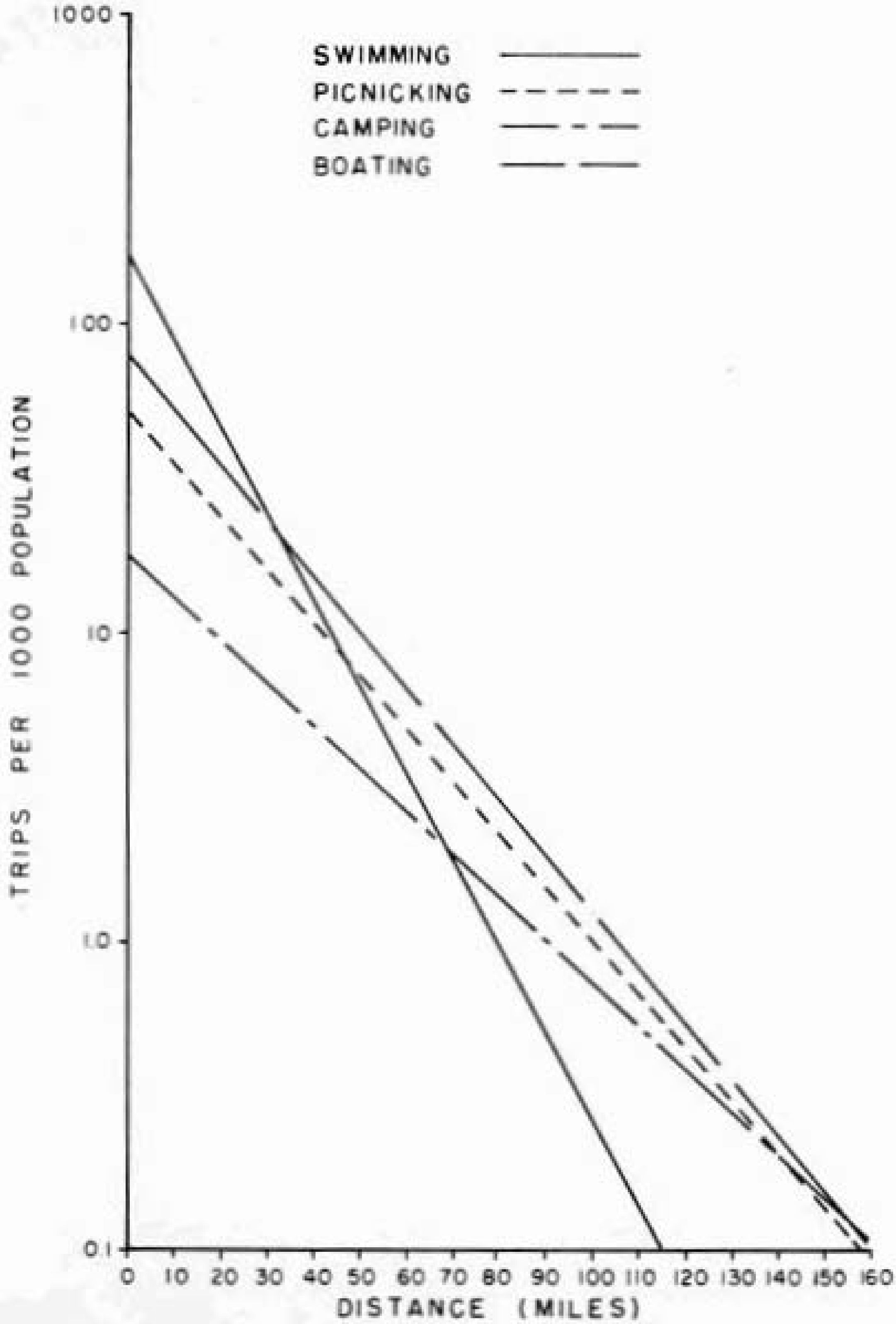

FIGURE 24

TRIP RATES BY PURPOSE FOR CLOSEST PARK - 1965

Persons Per Trip

The average number of persons per trip is shown in Table 7. The values were obtained by dividing the total number of people sampled who visited a park in a year by the total number of trips sampled in that same year. There is no significant difference among the values, the average value being 3.69 persons per trip.

TABLE 7

AVERAGE NUMBER OF PERSONS PER TRIP

	1965	1966
Raccoon	3.72	3.40
Cagles Mill	3.84	3.63
Monroe	3.80	3.63

Table 8 shows the average number of children per trip for each park for each year. It should be noted that for the parks and years when swimming was not allowed the number of children per trip was less than 1.0 and when swimming was permitted the value was greater than 1.0.

TABLE 8

AVERAGE NUMBER OF CHILDREN PER TRIP

	1965	1966
Raccoon	1.09	0.81
Cagles Mill	1.16	1.04
Monroe	0.93	0.85

Maximum Volume

Some knowledge of the maximum expected weekend volume could be of interest to planners. In order to determine the maximum weekend attendance, the maximum number of trips for a weekend for Raccoon and Cagles Mill were found for 1965 and 1966. The State Department of Natural Resources weekly tally sheets were used in order to obtain the exact number of trips for Cagles Mill in 1966. Sufficient data for 1965 were not available since only abbreviated tally sheets were made available. For this reason, the observed study values for the highest volume weekend were used.

The results are given in Table 9 and are stated in terms of percent of total annual trips as listed by the Department of Natural Resources. The average value is 6.9 percent.

TABLE 9

PERCENT OF TOTAL ANNUAL TRIPS OCCURRING ON MAXIMUM VOLUME WEEKEND

	Total Annual Trips	Maximum Weekend Volume	Percent of Total
1965 Raccoon	57,146	2,778	4.8
1965 Cagles Mill	30,695	2,431	7.9
1966 Cagles Mill	41,322	3,329	8.1

The maximum number of trips occur on Sunday. For any weekend when weather conditions are similar, Sunday will have the maximum volume of arriving trips. For the maximum weekends listed in Table 9, the daily breakdown is listed in Table 10.

TABLE 10

DAILY TRIPS ON MAXIMUM VOLUME WEEKEND

	Sunday	Saturday	Friday	Percent of Weekend Trips Occuring As Sunday Trips
1965 Raccoon	1,419	865	494	51.0
1965 Cagles Mill	1,276	748	407	52.5
1966 Cagles Mill	1,938	766	625	57.2

For planning purposes, the maximum volume that will be expected can be computed easily from the estimated total arrival trip volume. Since the Sunday trips of the maximum volume weekend account for, on the average, 53.5 percent of the total trips, 0.535 multiplied by 6.9 percent of the total annual trips will give an estimate of the maximum number of trips that can be expected in one day. Therefore, approximately 3.7 percent of the total annual trips can be expected as the maximum daily volume.

Return Visitors

The percentage of visitors who visit the parks more than once in a year was determined by the letter interviews conducted during the fall and winter of 1965. Eighty-three percent of those who sent back the questionnaires indicated that they had visited the parks more than once. The average number of visits to that park per person interviewed was 8.5. The percentage of multiple visits may be taken as a measure of user satisfaction. Comments on the questionnaire indicated little dissatisfaction with the type of facilities available or with the manner in which the parks are operated.

Land Value Changes

In order to investigate the land value increases in the vicinity of a reservoir and to measure this effect, land value information was obtained from the deeds on file in the respective county courthouses. Two groups of land values were determined for each reservoir. One group was designated the control group and consisted of randomly selected parcels of land that were not within five miles of the reservoir. The second group was composed of land parcels within one mile of the reservoir.

Land value was determined from the Federal Revenue Stamps required on deeds. These stamps are placed on the deed and give a measure of the stated purchase price. Previous work by this author has shown this method to be effective (15).

Only unimproved parcels were considered since there is no practical way on the deed to separate the cost of improvements from the cost of the land. Parcels that were transferred between related persons were also ignored as the cost of land in such transactions may not represent the true value of the land. Land bought by the Government was not included in the sample.

In order to make comparisons, the average cost of an acre was determined for both groups of land for each park for two year periods. Two year periods were used in order to have enough samples for a meaningful average. The results are shown in Figures 25, 26, and 27. The curves were fitted by linear regression techniques. It is evident that there is a difference in the value of land near a reservoir in comparison to similar land that is not near a reservoir. There seems to be quite a bit

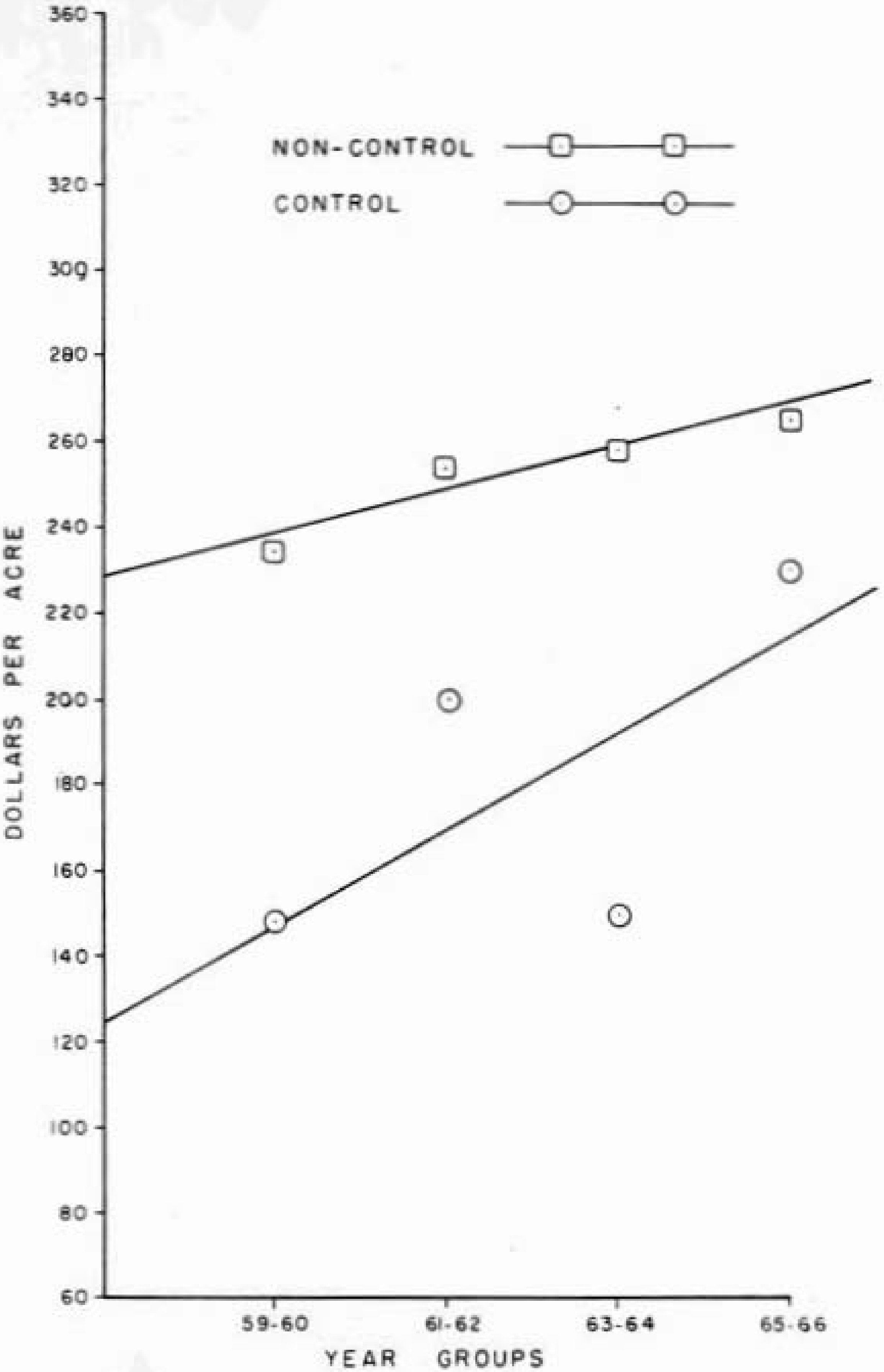

FIGURE 25

LAND VALUES FOR RACCOON

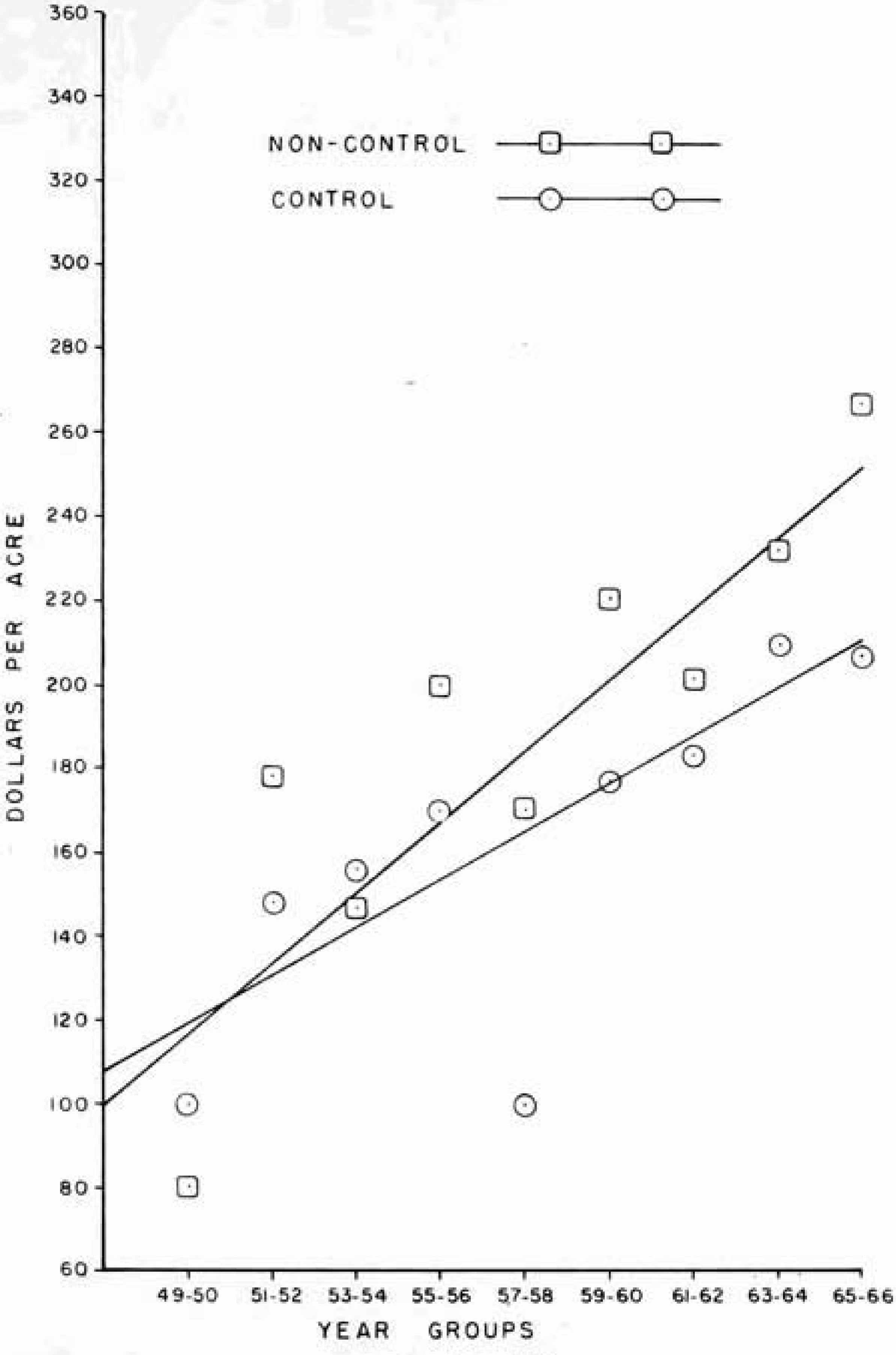

FIGURE 26

LAND VALUES FOR CAGLES MILL

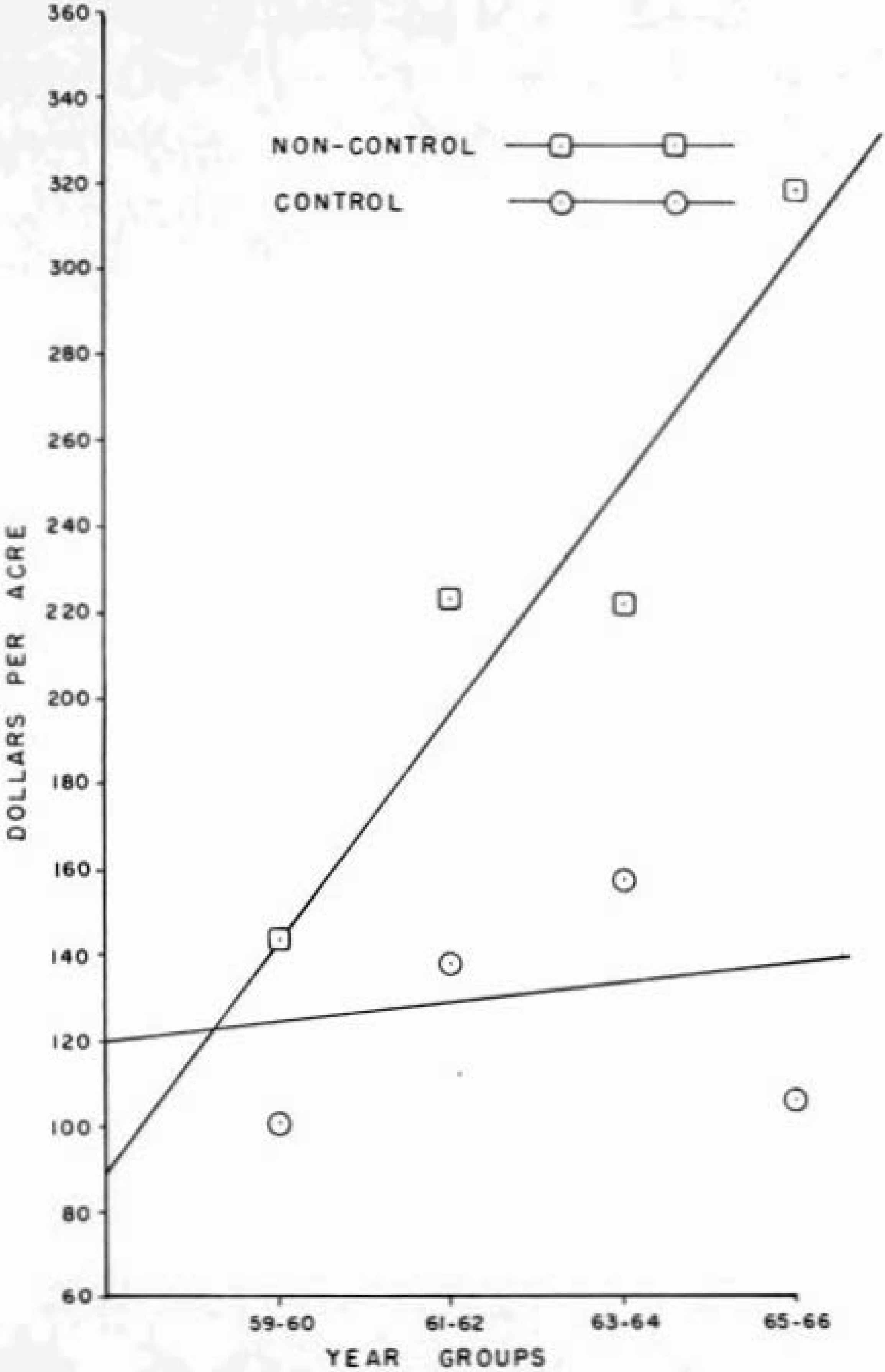

FIGURE 27
LAND VALUES FOR MONROE

of variation among the reservoirs as to cost differential. The first value plotted for each curve is for the two year period when the Government began buying land for the reservoir.

APPLICATION OF PREDICTION TECHNIQUE

Total Annual Trip Predictions for Wildcat Reservoir for 1975 and 1980

In order to clarify the procedure used to estimate future trip attractions to a reservoir, an example will be illustrated. Wildcat Reservoir has recently been authorized for construction by the United States Congress. The Reservoir will be located on Wildcat Creek a few miles east of Lafayette and it is anticipated that recreational facilities will be developed that are similar to those in the parks that were studied. 1975 and 1980 were selected as the design years for the example.

As the exact location of the park is not known, it is assumed to be five miles east of the center of Lafayette. The first step in problem design is to list all counties within 125 road miles of this location. The determination of which counties are closer to some other similar park than they are to the proposed Wildcat Reservoir Park was the second step. For this example, Indiana Dunes was assumed to be a similar facility.

The population projections used for this example are the best estimates for each Indiana County as estimated in a report by the Graduate School of Business of Indiana University [16]. Of the three projections for each county, the recommended estimates were used. A straight line projection of the 1950-1960 census data was used for Illinois Counties.

The next step is to determine the projected 1975 population for each county within 125 miles of the reservoir. The method is therefore responsive to changes in the environment and it can be brought up to date by modifying only those parameters which have changed. The entire estimating procedure need not be redone each time a change is necessary; the flexibility of the process means only the affected portions need to be adjusted. For this example, no attempt has been made to account for possible changes in the trip rates.

The trip rates for each county for total trips are found by using Figure 28 for total annual trips to the closest park. Figure 29 is used to find total annual trips to a park which is influenced by an intervening park. The results are shown in Table 13. The total annual trips are 56,320. The number of total annual trips is multiplied by 1.20 in order to include in the estimate the 20 percent of trips that originate beyond 125 miles from the park. The result is the estimated total annual trips to the reservoir, 67,595.

The entire process was repeated for 1980. The trip rates are identical with the 1975 projections, but county population estimates are changed. Total annual trips predicted for 1980 are estimated 73,333.

As additional population data becomes available, the estimates can be adjusted easily. Road distance estimates can be modified also as improvements are made in the highway network.

The procedure can be summarized in the following manner:

1. Determine the location of the park.
2. Locate other similar parks.
3. Determine the road miles from counties within 125 miles of the park.

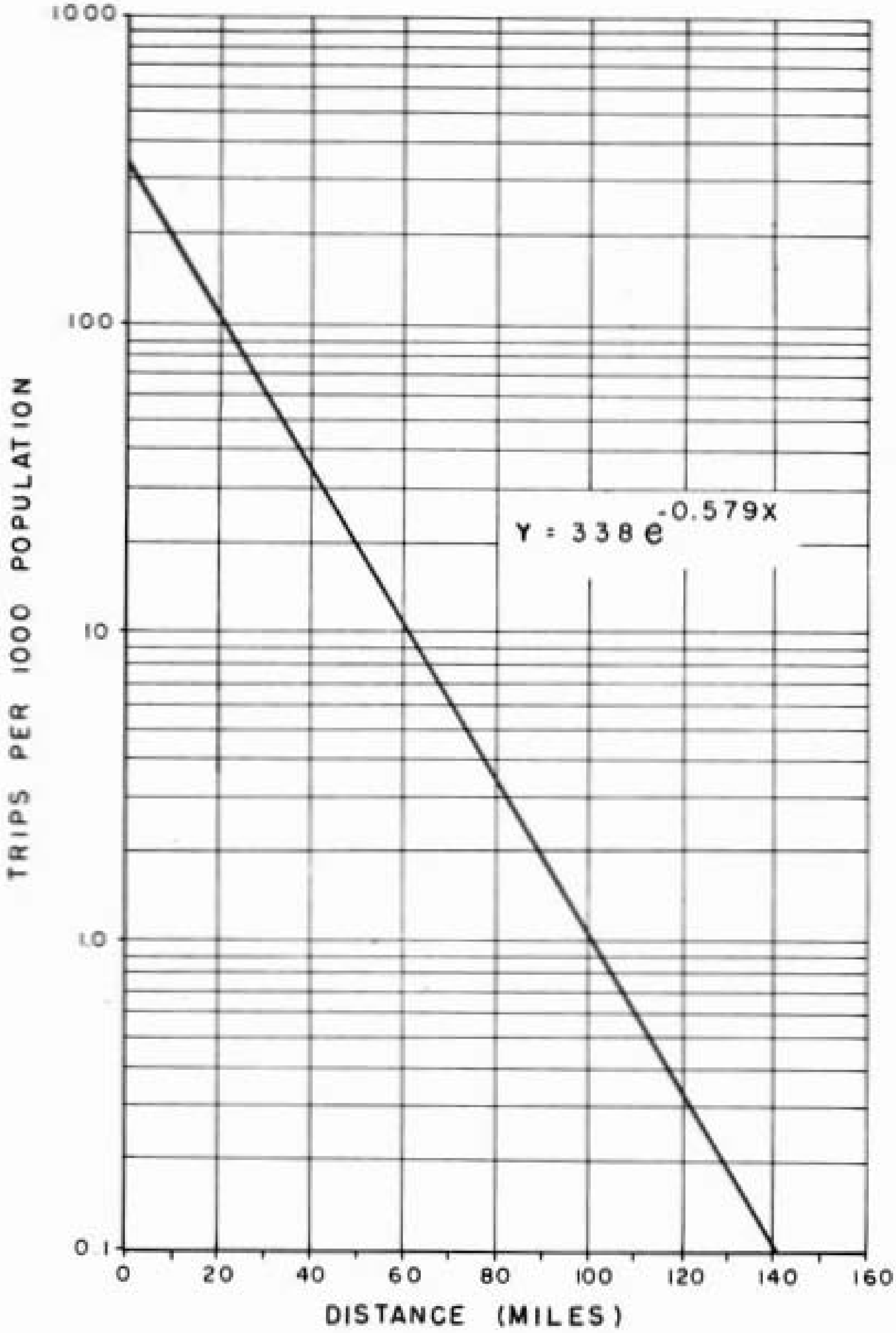

FIGURE 28
TOTAL TRIPS TO CLOSEST PARK

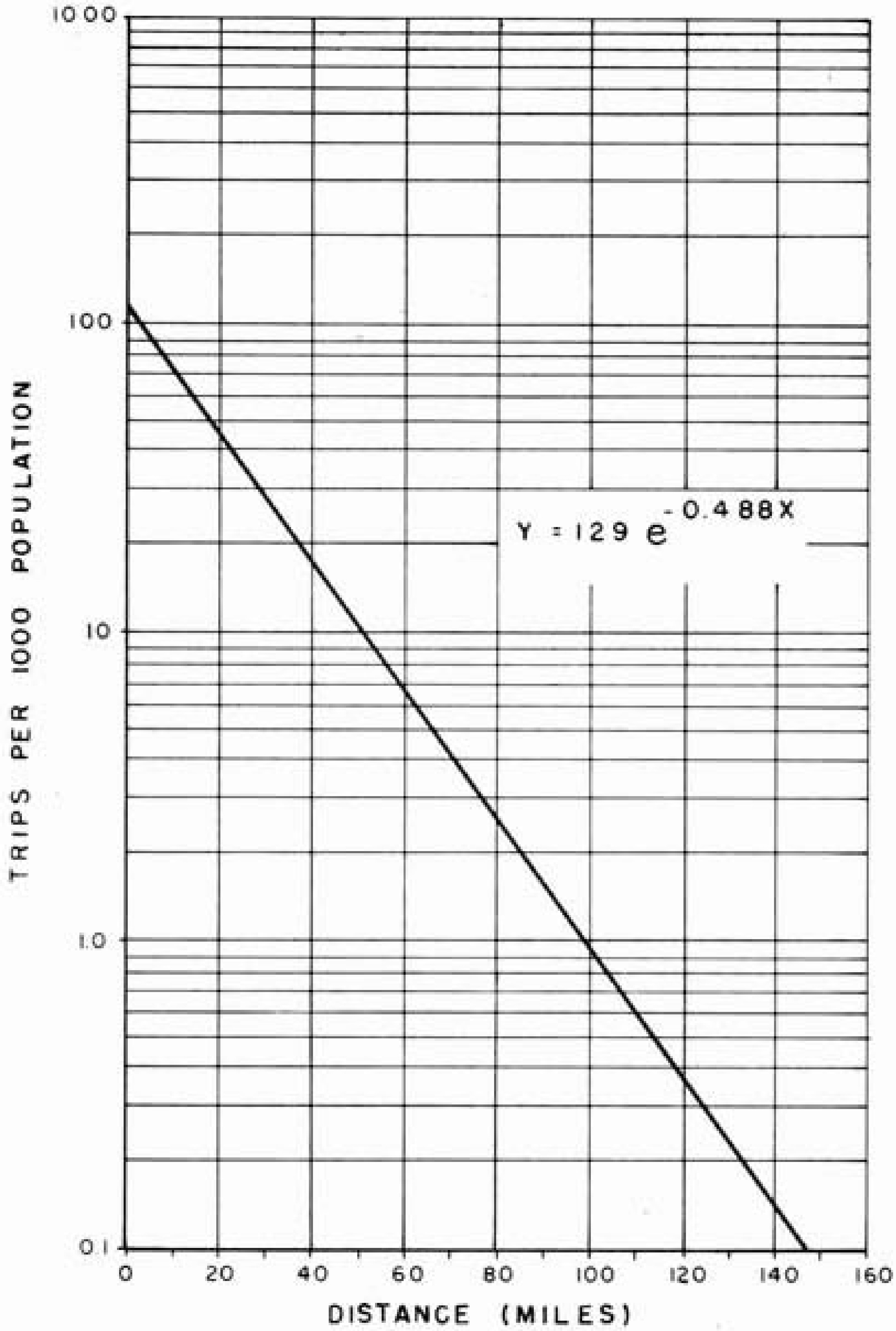

FIGURE 29
TOTAL TRIPS WITH INTERVENING PARK

4. Determine which counties are closer to some park other than the one of interest. List these in Table 17, page 106, Appendix C.

5. List remaining counties in Table 16, page 105, Appendix C.

6. For counties in Table 17 determine Y from Figure 28.

7. For counties in Table 16 determine Y from Figure 29.

8. Enter county population estimates for design year in Tables 16 and 17.

9. For both tables, multiply Y times population and sum all projects for each table and enter sums in Table 18, page 107, Appendix C.

10. Add the total summation of Tables 16 and 17. Multiply this sum by 1.20 to account for trips originating beyond 125 miles. The product is the estimated total annual trips.

TABLE II

WILDCAT, CLOSEST INDIANA COUNTIES

COUNTY	Y	X $\frac{POP}{1000}$ (1975) =	TRIPS	Y	X $\frac{POP}{1000}$ (1980) =	TRIPS
White	70	21.7	1519.00	70	22.4	1570.24
Carroll	52	17.4	904.80	52	17.6	915.20
Clinton	62	30.3	1878.60	62	30.0	1860.00
Warren	35	8.4	294.00	35	8.3	290.50
Benton	59	12.1	713.90	59	12.1	713.90
Jasper	14	21.2	296.80	14	22.1	309.40
Pulaski	8.4	12.5	105.00	8.4	12.4	104.16
Cass	35	42.8	1498.00	35	43.7	1529.50
Tipton	14	15.1	211.40	14	14.8	207.20
Boone	47	31.9	1499.30	47	33.6	1579.20
Hamilton	11	53.3	586.30	11	67.0	737.00
Tippecanoe	246	106.0	26,076.00	246	116.0	28,536.00
		TOTAL =	35,583.10		TOTAL =	38,352.30

TABLE 12

WILDCAT, INTERVENING INDIANA COUNTIES

COUNTY	Y	X $\frac{POP}{1000}$ (1975) =	TRIPS	Y	X $\frac{POP}{1000}$ (1980) =	TRIPS
Montgomery	29.00	37.0	1073.0	29.00	39.0	1131.0
Fountain	19.50	19.7	384.2	19.50	20.1	392.0
Lake	1.90	648.2	1231.6	1.90	699.7	1329.4
Porter	25.00	125.0	3125.0	25.00	162.0	4050.0
Newton	55.00	11.6	640.0	55.00	11.9	654.5
LaPorte	1.42	120.0	168.0	1.42	128.0	179.2
Starke	2.00	21.0	42.0	2.00	22.1	44.2
St. Joseph	1.12	287.4	316.2	1.12	309.0	339.9
Marshall	2.40	36.9	86.4	2.40	37.0	88.8
Fulton	6.40	16.7	106.9	6.40	16.6	106.2
Elkhart	0.55	[illegible]	90.9	0.55	172.0	103.7
Kosciusko	1.72	51.5	92.7	1.72	60.3	102.5
Noble	0.23	33.0	6.6	0.23	35.5	7.1
Whitley	0.60	23.5	14.1	0.60	24.0	14.4
Allen	0.72	317.7	222.4	0.72	357.6	250.3
Miami	0.82	47.3	37.8	0.82	51.0	40.8
Wabash	3.55	38.3	137.2	3.55	40.2	144.7

TABLE 12 (CONTINUED)

COUNTY	Y	X $\frac{POP}{1000}$ (1975) =	TRIPS	Y	X $\frac{POP}{1000}$ (1980) =	TRIPS
Huntington	1.50	37.7	56.6	1.50	39.5	59.3
Wells	0.63	24.0	14.4	0.63	25.0	15.0
Adams	0.35	26.1	10.4	0.35	26.6	10.6
Howard	12.00	97.9	1174.8	12.00	110.4	1324.8
Grant	3.60	100.9	363.2	3.60	112.0	403.2
Blackford	1.00	15.3	27.5	1.80	15.5	27.9
Jay	0.66	21.1	14.8	0.66	20.5	14.4
Madison	1.55	155.0	263.5	1.65	175.0	297.5
Delaware	1.12	146.2	160.8	1.12	159.9	175.9
Randolph	0.39	29.0	11.6	0.39	29.2	11.7
Hendricks	7.40	72.0	532.8	7.40	89.9	665.3
Marion	6.10	860.0	5346.0	6.10	900.0	5490.0
Hancock	2.20	39.7	87.3	2.20	46.0	101.2
Henry	0.30	50.5	15.2	0.30	50.8	15.3
Rush	0.90	20.4	18.4	0.90	20.4	18.4
Vermillion	7.40	14.4	106.6	7.40	13.3	98.4
Parke	5.00	13.0	65.0	5.00	12.4	62.0

TABLE 12 (CONTINUED)

COUNTY	Y	X $\frac{POP}{1000}$ (1975)	= TRIPS	Y	X $\frac{POP}{1000}$ (1980)	= TRIPS
Putnam	6.70	28.1	168.2	6.7	29.1	195.0
Morgan	1.10	50.0	55.0	1.10	56.0	61.6
Johnson	2.20	79.0	173.8	2.20	100.0	220.0
Shelby	1.90	43.0	81.7	1.90	46.0	87.4
Decatur	0.80	22.7	18.2	0.80	23.8	19.0
Ripley	0.20	23.8	4.8	0.20	25.3	5.1
Bartholomew	0.70	72.5	50.8	0.70	84.0	58.8
Jennings	0.4	20.7	8.3	0.40	22.2	8.9
Brown	0.70	8.0	5.6	0.70	8.3	5.8
Lawrence	0.40	36.9	14.8	0.40	36.8	14.7
Monroe	1.10	78.36	86.2	1.10	86.4	95.0
Owen	3.00	10.3	30.9	3.00	9.9	29.7
Clay	2.30	23.3	53.6	2.30	23.0	53.9
Vigo	2.00	111.1	222.2	2.00	112.0	224.0
Sullivan	0.40	18.2	7.3	0.40	17.0	6.8
Greene	0.80	22.6	18.1	0.80	21.0	16.8
	TOTAL	=	16,953.8	TOTAL	=	18,871.1

TABLE 13

WILDCAT, ILLINOIS COUNTIES

COUNTY	Y	x $\frac{POP}{1000}$ (1975) =	TRIPS	Y	x $\frac{POP}{1000}$ (1980) =	TRIPS
Cook	.34	6061.2	2060.808	.34	6371.6	2166.344
Will	.67	277.5	185.925	.67	306.2	205.154
Kankakee	1.70	118.4	201.280	1.70	127.1	216.070
Iroquois	5.60	35.4	198.240	5.60	36.0	201.600
Livingston	.32	44.1	14.112	.32	45.4	14.528
Ford	2.00	17.7	35.400	2.0	18.0	36.000
McLean	.29	94.8	27.492	.29	98.5	28.565
Vermillion	7.50	109.8	823.500	7.50	114.4	858.000
Champaign	1.14	171.9	195.966	1.14	185.1	211.014
Dewitt	.205	17.8	3.649	.205	18.0	3.620
Edgar	.76	23.8	18.088	.76	24.3	18.468
Douglas	.57	23.0	13.110	.57	24.3	13.851
Clark	.32	17.8	5.696	.32	18.2	5.824
Piatt	.51	16.4	8.364	.51	17.0	8.670
		TOTAL =	3791.630		TOTAL =	3887.778

TABLE 14

WILDCAT, TOTAL TRIPS

	1975 TRIPS	1980 TRIPS
INDIANA CLOSEST	35,583.1	38,352.3
ILLINOIS COUNTIES	3,791.6	3,887.8
INDIANA INTERVENING	16,953.8	18,871.1
TOTALS	56,328.5	61,111.2

FOR ESTIMATE, ROUND OFF TO THE NEAREST 100.

CONCLUSIONS AND RECOMMENDATIONS

The objective of this research was to develop a method of predicting attendance for recreational purposes at new reservoirs. The method developed by this research appears to be an effective tool for predicting future recreational attendance at reservoir parks. The model $Y = Ae^{-Bx}$ is able to produce accurate trip estimates to a reservoir if the trip rates are placed into two categories, trips to the closest park and trips with an intervening park.

The model for the case of total annual trips to the closest park is $Y = 338.4e^{-0.5791X}$. When there is an intervening park, the model becomes $Y = 129.3e^{-0.4875X}$. Distance measured in tens of miles and population measured in thousands are the two variables necessary to use the equations which will produce annual trip rates for a county.

The method developed is able to predict future attendance with reasonable accuracy based on distance, population, and the influence of similar parks. In contrast to the previously developed models which require many socio-economic and park characteristics variables which are difficult to measure and evaluate and extremely difficult to project, this model is probably as accurate and is much simpler to use. The model is adequate for advanced planning purposes and can be used to predict reservoir attendance and traffic volume estimates.

Statistical evidence indicates that there is no significant difference between parks of similar type with regard to their ability to attract visitors. There is one attraction rate for trips to a reservoir that is closer to the point of trip origin than another reservoir and another attraction rate for trips when there is another reservoir closer to the point of trip origin than the reservoir being considered. The difference in attraction rates substantiates the assumption that a trip desires to be as short as possible. People will not go past a park to get to another that has similar facilities.

The county trip rate to a park is also directly related to the distance between the county and the park; the longer the distance, the smaller the trip rate per 1000 population for that county.

The attendance at any proposed site is dependent on the population, its distance from that park, and the location of other similar parks with regard to the location of the population. These parameters are easily understood and readily available to any planning agency. Distance can be determined from an official state highway map. Population data and projection techniques are common tools for the planner.

Growth of the trip rates is a possibility, but was not included in this report because a two year time period is not sufficient for an accurate examination of the possible changes in trip rates. The continuing phase of this project should investigate possible growth of the trip rate.

The trip rate appears to be a handy tool. The high correlation index values (R^2) for total trips (.84 to .97) indicates that the trip rate technique was effective in eliminating county population variations. The correlation index values also tend to validate the assumption that socio-economic factors and park facility quantities can be considered uniform in that all parks tend to draw trips from what is essentially a uniform cross section of all types of social and economic population groups.

The single purpose trips have correlation indices (R^2) that are smaller than those for total trips. The single purpose trips were used only to establish the relative attraction of each purpose and no attempt was made to predict attendance based on single trip purposes. It is difficult to isolate the influence of a single trip purpose from the multi-purpose trips.

The changes in land value surrounding the reservoirs studied does not appear to exhibit related behavior. While the value of land within one mile of a reservoir invariably shows a substantial increase over the control property, the difference in value varies considerably between the three parks studied. This is, however, due in part to the variations in the soil, terrain, and other factors. Further study should be made in order to develop a more useful method of measuring changes in land value. The lack of correlation between the land values observed in the study precludes any inferences on estimating land value changes at other locations, other than to say that some increase will occur within one mile of the reservoir. This increase is attributed to recreation since there can be no other logical explanation of the increase. The increase in the number of subdivided parcels, restaurants, bait shops, and other service facilities indicates the reason for a good portion of the increased land values.

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APPENDIX A

APPENDIX A

RESERVOIR STUDY

FACILITY________ DATE________ DAY________ WEATHER________

COLLECTED BY________

TIME	COUNTY OF RESIDENCE (OUT OF STATE)	ACTIVITY (SEE CODE)	NUMBER UNDER 12	NUMBER IN CAR	EQUIPMENT HAULED (SEE CODE)	LICENSE NUMBER	REMARKS
1200		SPB		2		79C 1007	
1200	MARION (49)	PS	4	6		VIRGINIA	VISITING
1200		BFPS	1	3		54B 2001	
1300	VERMILLION	CBSFP	1	4		427M5	ILLINOIS
1300	HAMILTON	C	2	4	MN	46740Y	TRUCK
1400		BCSH		1	J	79A 5940	
1400		BCS	4	6	JM	32B 1896	
1500	MACON	CSH	3	5	K	EU 6264	ILLINOIS
1500	LAKE	CP	2	4	N	91064Y	TRUCK
1600	LOS ANGELES	S	1	3		JDL 623	CAL. VISITING
1600	DOUGLAS	CFSPO	2	3	M	608197	ILLINOIS

FIGURE 30

DATA COLLECTION SHEET

ACTIVITY CODE

B - Boating

C - Camping

F - Fishing

H - Hiking

L - Looking around

P - Picnic

S - Swimming

O - Other (make note)

EQUIPMENT CODE

J - Boat

K - Camping trailer

M - House trailer

N - Camper (bus, truck, etc.)

FIGURE 31. Activity Code

1. Approximately how many times did you visit Lieber State Park during 1965? ________.

2. Have you ever visited this park before 1965? Yes____, No ____.

3. Is it likely that you will visit this park again? Yes____, No____.

4. Were you satisfied with the existing facilities? Yes____, No____.

   Comments____

   ____

   ____

5. What facilities would you like to have added to the park? ________

   ____

   ____

6. Please give an estimate of the total number of recreational trips of this type that you made in 1965 to all Parks. __________.

FIGURE 32. Interview Letter

APPENDIX B

APPENDIX B

SUMMARIZATION PROGRAM FOR 7094 COMPUTER

This program uses FORTRAN IV Computer language. The input to the program is the interview information. Each interview is one entry. All interviews are mounted on tape and are on file with the Joint Highway Research Project.

The advantage of this program is that each trip is recorded only once for any summation regardless of which type of trip or trips is being summed. Trips can be summed for any county, park, state, trip purpose, day, month, hour of arrival, weather conditions, or by equipment carried. Any desired combination of the above can also be used for summation of trips.

Logical IF statements can be inserted to achieve the desired summation. If statements are inserted after card statement 3, which is "3 IF(PK.GT.3) go to 206." If for example, the statement IF (PER.N.E.1) Go to 1 is placed into the program, only 25 percent samples will be summed. If any other percentage value is in the percentage column (PER), that data entry is rejected and the program reads the next entry. If the logical IF statement is not satisfied, then the program goes to the next data entry. The summation program, utilizing over 13,000 data entries, is able to complete a summation in approximately 140 seconds.

TABLE 15

SUMMATION PROGRAM

```
     $ID     3214*10*50**MATTHIAS**
             $IBSYS
             $IBSYS
             $*  MOUNT TAPE PURDUE 204 ON A5, RING OUT, LOW DENSITY
             $PAUSE          CONTINUE WHEN READY
             OPER. ACTION PAUSE

             ..CONTINUING

             $ATTACH         A5
             $AS             SYSCK1,LOW
             $EXECUTE        IBJOB
IBJOB VERSION 5 HAS CONTROL.
$IBJOB
$IBFTC MAIN
      INTEGER BO(2,3),CO(2,3),FO(2,3),PO(2,3),OO(2,3),SO(2,3),HO(2,3),L
     1O(2,3),BC(2,3),BF(2,3),BP(2,3).BS(2,3),BH(2,3),CF(2,3).CP(2,3),CS(
     22,3),CH(2,3),FP(2,3),FS(2,3),FH(2,3),PS(2,3),PH(2,3),SH(2,3),BCF(2
     3,3),BCP(2,3),BCS(2,3),BCH(2,3),BFP(2,3),BFS(2,3),BFH(2,3),BPS(2,3)
     4,BPH(2,3),BSH(2,3),CFP(2,3),CFS(2,3),CFH(2,3),CPS(2,3),CPH(2,3),CS
     5H(2,3),FPS(2,3),FPH(2,3),FSH(2,3),PSH(2,3),BCFP(2,3),BCFS(2,3),BCF
     6H(2,3),BCPS(2,3),BCPH(2,3),BFPS(2,3),BFPH(2,3),BCSH(2,3),BFSH(2,3)
     7,CFPS(2,3),CFPH(2,3),CFSH(2,3),FPSH(2,3),CPSH(2,3),BPSH(2,3),BCFPS
     9(2,3),BCFPH(2,3),BFPSH(2,3),BCFSH(2,3),BCPSH(2,3),CFPSH(2,3),BCFPS
     AH(2,3),PK,YR,PER,B,C,F,P,O,S,H,L,PEOPLE, MONTH, COUNTY, STATE
401 DO 502 I=1,2
402 DO 501 J=1,3
403 BO(I,J)=0
404 CO(I,J)=0
405 FO(I,J)=0
406 PO(I,J)=0
407 OO(I,J)=0
408 SO(I,J)=0
409 HO(I,J)=0
410 LO(I,J)=0
411 BC(I,J)=0
412 BF(I,J)=0
413 BP(I,J)=0
414 BS(I,J)=0
415 BH(I,J)=0
416 CF(I,J)=0
417 CP(I,J)=0
```

TABLE 15 (cont'd.)

```
418 CS(I,J)=0
419 CH(I,J)=0
420 FP(I,J)=0
421 FS(I,J)=0
422 FH(I,J)=0
423 PS(I,J)=0
424 PH(I,J)=0
425 SH(I,J)=0
426 BCF(I,J)=0
427 BCP(I,J)=0
428 BCS(I,J)=0
429 BCH(I,J)=0
430 BFP(I,J)=0
431 BFS(I,J)=0
432 BFH(I,J)=0
433 BPS(I,J)=0
434 BPH(I,J)=0
435 BSH(I,J)=0
436 CFP(I,J)=0
437 CFS(I,J)=0
438 CFH(I,J)=0
439 CPS(I,J)=0
440 CPH(I,J)=0
441 CSH(I,J)=0
442 FPS(I,J)=0
443 FPH(I,J)=0
444 FSH(I,J)=0
445 PSH(I,J)=0
446 BCFP(I,J)=0
447 BCFS(I,J)=0
448 BCFH(I,J)=0
449 BCPS(I,J)=0
450 BCPH(I,J)=0
451 BFPS(I,J)=0
452 BFPH(I,J)=0
453 BCSH(I,J)=0
454 BPSH(I,J)=0
455 CFPS(I,J)=0
456 CFPH(I,J)=0
457 CFSH(I,J)=0
458 FPSH(I,J)=0
459 CPSH(I,J)=0
460 BFSH(I,J)=0
461 BCFPS(I,J)=0
462 BCFPH(I,J)=0
463 BFPSH(I,J)=0
464 BCFSH(I,J)=0
465 BCPSH(I,J)=0
```

TABLE 15 (cont'd.)

```
466 CFPSH(I,J)=0
467 BCFPSH(I,J)=0
501 CONTINUE
502 CONTINUE
  1 READ (8,2) PK,MONTH,YR,PER,COUNTY,STATE,PEOPLE,B,C,F,P,G,S,H,L   143
  2 FORMAT (I1,3X,I2,4X,I1,5X,I1,4X,I2,1X,I2,3X,I2,4X,8I1)
  3 IF (PK .GT.3) GO TO 206
  4 IF (PER .NE.1) GO TO 1
  5 I = YR
  6 J = PK
 10 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.0)
   1GO TO 76
 11 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.0)
   1GO TO 78
 12 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.0)
   1GO TO 80
 13 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.0)
   1GO TO 82
 14 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.0)
   1GO TO 84
 15 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.0.AND.G.EQ.1.AND.S.EQ.0.
   1AND.H.EQ.0) GO TO 86
 16 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.1)
   1GO TO 88
 17 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.0)
   1AND.L.EQ.1) GO TO 90
 18 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.0)
   1GO TO 92
 19 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.0)
   1GO TO 94
 20 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.0)
   1GO TO 96
 21 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.0)
   1GO TO 98
 22 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.1)
   1GO TO 100
 23 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.0)
   1GO TO 102
 24 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.0)
   1GO TO 104
 25 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.0)
   1GO TO 106
 26 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.1)
   1GO TO 108
 27 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.0)
   1GO TO 110
 28 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.0)
   1GO TO 112
```

TABLE 15 (cont'd.)

```
29 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.1)
  1GO TO 114
30 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.0)
  1GO TO 116
31 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.1)
  1GO TO 118
32 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.1)
  1GO TO 120
33 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.0)
  1GO TO 122
34 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.0)
  1GO TO 124
36 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.0)
  1GO TO 126
37 IF (B.EQ.1.AND.C.EQ.1.AND F.EQ.0.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.1)
  1GO TO 128
38 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.0)
  1GO TO 130
39 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.0)
  1GO TO 132
40 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.1)
  1GO TO 134
41 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.0)
  1GO TO 136
42 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.1)
  1GO TO 138
43 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.1)
  1GO TO 140
44 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.0)
  1GO TO 142
45 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.0)
  1GO TO 144
46 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.1)
  1GO TO 146
47 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.0)
  1GO TO 148
48 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.1)
  1GO TO 150
49 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.1)
  1GO TO 152
50 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.0)
  1GO TO 154
51 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.1)
  1GO TO 156
52 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.1)
  1GO TO 158
54 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.1)
  1GO TO 160
```

TABLE 15 (cont'd.)

```
 56 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.0)
   1GO TO 162
 57 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.0)
    1GO TO 164
 58 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.0.AND.H.EQ.1)
    1GO TO 166
 59 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.0)
    1GO TO 168
 60 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.1)
    1GO TO 170
 61 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.0)
    1GO TO 172
 62 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.1)
    1GO TO 174
 63 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.1)
    1GO TO 176
 64 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.1)
    1GO TO 178
 65 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.1.AND H.EQ.0)
    1GO TO 180
 66 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.0)
    1GO TO 182
 67 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.1)
    1GO TO 184
 68 IF (B.EQ.0.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.1)
    1GO TO 186
 69 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.1)
    1GO TO 188
 70 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.1)
    1GO TO 190
 71 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.0)
    1GO TO 192
 72 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.0.AND.H.EQ.0)
    1GO TO 194
 73 IF (B.EQ.1.AND.C.EQ.0.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.1)
    1GO TO 196
 74 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.0.AND.S.EQ.1.AND.H.EQ.1)
    1GO TO 198
 75 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.0.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.1)
    1GO TO 200
300 IF (B.EQ.0.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.1)
   1GO TO 202
301 IF (B.EQ.1.AND.C.EQ.1.AND.F.EQ.1.AND.P.EQ.1.AND.S.EQ.1.AND.H.EQ.1)
   1GO TO 204
 76 BO     (I,J)= BO     (I,J)+1
 77 GO TO 1
 78 CO     (I,J)= CO     (I,J)+1
 79 GO TO 1
```

TABLE 15 (cont'd.)

```
 80 FO     (I,J)= FO     (I,J)+1
 81 GO TO 1
 82 PO     (I,J)= PO     (I,J)+1
 83 GO TO 1
 84 SO     (I,J)= SO     (I,J)+1
 85 GO TO 1
 86 CO     (I,J)= CO     (I,J)+1
 87 GO TO 1
 88 HO     (I,J)= HO     (I,J)+1
 89 GO TO 1
 90 LO     (I,J)=LO      (I,J)+1
 91 GO TO 1
 92 BO     (I,J)= BO     (I,J)+1
 93 GO TO 1
 94 BP     (I,J)= BP     (I,J)+1
 95 GO TO 1
 96 BF     (I,J)= BF     (I,J)+1
 97 GO TO 1
 98 BS     (I,J)= BS     (I,J)+1
 99 GO TO 1
100 BH     (I,J)= BH     (I,J)+1
101 GO TO 1
102 CP     (I,J)= CP     (I,J)+1
103 GO TO 1
104 CF     (I,J)= CF     (I,J)+1
105 GO TO 1
106 CS     (I,J)= CS     (I,J)+1
107 GO TO 1
108 CH     (I,J)= CH     (I,J)+1
109 GO TO 1
110 FP     (I,J)= FP     (I,J)+1
111 GO TO 1
112 FS     (I,J)= FS     (I,J)+1
113 GO TO 1
114 FH     (I,J)= FH     (I,J)+1
115 GO TO 1
116 PS     (I,J)= PS     (I,J)+1
117 GO TO 1
118 PH     (I,J)= PH     (I,J)+1
119 GO TO 1
120 SH     (I,J)= SH     (I,J)+1
121 GO TO 1
122 BCF    (I,J)= BCF    (I,J)+1
123 GO TO 1
124 BCP    (I,J)= BCP    (I,J)+1
125 GO TO 1
126 BCS    (I,J)= BCS    (I,J)+1
127 GO TO 1
```

TABLE 15 (cont'd.)

```
128 BCH  (I,J)= BCH  (I,J)+1
129 GO TO 1
130 BFP  (I,J)= BFP  (I,J)+1
131 GO TO 1
132 BFS  (I,J)= BFS  (I,J)+1
133 GO TO 1
134 BFH  (I,J)= BFH  (I,J)+1
135 GO TO 1
136 BPS  (I,J)= BPS  (I,J)+1
137 GO TO 1
138 BPH  (I,J)= BPH  (I,J)+1
139 GO TO 1
140 BSH  (I,J)= BSH  (I,J)+1
141 GO TO 1
142 CFP  (I,J)= CFP  (I,J)+1
143 GO TO 1
144 CFS  (I,J)= CFS  (I,J)+1
145 GO TO 1
146 CFH  (I,J)= CFH  (I,J)+1
147 GO TO 1
148 CPS  (I,J)= CPS  (I,J)+1
149 GO TO 1
150 CPH  (I,J)= CPH  (I,J)+1
151 GO TO 1
152 CSH  (I,J)= CSH  (I,J)+1
153 GO TO 1
154 FPS  (I,J)= FPS  (I,J)+1
155 GO TO 1
156 FPH  (I,J)= FPH  (I,J)+1
157 GO TO 1
158 FSH  (I,J)= FSH  (I,J)+1
159 GO TO 1
160 FSH  (I,J)= FSH  (I,J)+1
161 GO TO 1
162 BCFP (I,J)=BCFP  (I,J)+1
163 GO TO 1
164 BCFS (I,J)= BCFS (I,J)+1
165 GO TO 1
166 BCFH (I,J)= BCFH (I,J)+1
167 GO TO 1
168 BCPS (I,J)= BCPS (I,J)+1
169 GO TO 1
170 BCPH (I,J)= BCPH (I,J)+1
171 GO TO 1
172 BFPS (I,J)= BFPS (I,J)+1
173 GO TO 1
174 BFPH (I,J)= BFPH (I,J)+1
175 GO TO 1
```

TABLE 15 (cont'd.)

```
176 BCSH  (I,J)= BCSH  (I,J)+1
177 GO TO 1
178 BPSH  (I,J)= BPSH  (I,J)+1
179 GO TO 1
180 CFPS  (I,J)= CFPS  (I,J)+1
181 GO TO 1
182 CFPH  (I,J)= CFPH  (I,J)+1
183 GO TO 1
184 CFSH  (I,J)= CFSH  (I,J)+1
185 GO TO 1
186 FPSH  (I,J)= FPSH  (I,J)+1
187 GO TO 1
188 CPSH  (I,J)= CPSH  (I,J)+1
189 GO TO 1
190 BFSH  (I,J)= BFSH  (I,J)+1
191 GO TO 1
192 BCFPS (I,J)= BCFPS (I,J)+1
193 GO TO 1
194 BCFPH (I,J)= BCFPH (I,J)+1
195 GO TO 1
196 BFPSH (I,J)= BFPSH (I,J)+1
197 GO TO 1
198 BCFSH (I,J)= BCFSH (I,J)+1
199 GO TO 1
200 BCPSH (I,J)= BCPSH (I,J)+1
201 GO TO 1
202 CFPSH (I,J)= CFPSH (I,J)+1
203 GO TO 1
204 BCFPSH(I,J)= BCFPSH(I,J)+1
205 GO TO 1
206 WRITE (6,208)                                                            622
207 WRITE (6,209) BO,CO,FO,PO,GO,SO,HO,LO,BC,BF,BP,BS,BH,CF,CP,CS,CH,
   1FT,FS,FH,PS,PH,SH,BCF,BCP,BCS,BCH,BFT,BFS,BFH,BPS,BPH,BSH,CFP,CFS,
   1CFH,CPS,CPH,CSH,FPS,FPH,FSH,PSH,BCFP,BCFS,BCFH,BCPS,BCPH,BFPS,BFPH
   1,BCSH,BFSH,CFPS,CFPH,CFSH,FPSH,CPSH,BPSH,BCFPS,BCFPH,BFPSH,BCFSH,
   1BCPSH,CFPSH,BCFPSH                                                      623
208 FORMAT (6HPARK 1,5X,6HPARK 1,5X,6HPARK 2,5X,6HPARK 2,5X,6HPARK 3,
   15X,6HAPRK 3/6HYEAR 1,5X,6HYEAR 2,5X,6HYEAR 1,5X,6HYEAR 2,5X,
   16HYEAR 1,5X,6HYEAR 2)
209 FORMAT (6(I5,6X))
400 STOP
    END
```

TABLE 15 (cont'd.)

$DATA

EXECUTION

PARK 1 YEAR 1	PARK 1 YEAR 2	PARK 2 YEAR 1	PARK 2 YEAR 2	PARK 3 YEAR 1	PARK 3 YEAR 2
452	570	153	359	185	420
130	216	79	101	14	17
107	328	36	108	13	8
264	240	91	129	32	92
239	134	69	95	40	63
500	23	199	300	2	119
3	12	0	6	0	1
407	535	62	281	640	1004
49	56	30	29	10	25
139	187	28	71	6	0
279	81	100	85	89	109
109	25	54	49	9	25
0	1	0	0	0	2
66	109	19	35	0	0
27	7	3	3	6	1
117	6	85	14	0	0
6	6	2	0	0	0
42	43	14	17	1	0
43	1	11	13	0	0
0	1	0	0	0	0
375	9	216	134	1	7
2	5	1	2	1	0
6	0	1	2	0	0
40	34	15	11	0	0
10	1	0	1	5	0
40	4	34	6	2	0
4	1	0	0	0	0
42	11	17	9	1	0
18	3	7	1	0	0
0	0	0	0	0	0
122	6	98	26	9	9
1	0	0	1	0	0
6	6	0	1	0	0
97	6	54	21	1	0
4	2	0	2	0	0
16	1	3	1	0	1
1	2	0	0	0	0
27	1	17	4	0	0
52	2	17	11	0	0
0	1	0	0	0	0
1	0	1	0	0	0
13	2	6	5	2	0
1	5	0	0	0	0

TABLE 15 (cont'd.)

42	1	39	4	0	0
1	0	1	0	0	0
10	0	1	0	0	1
0	1	0	0	0	0
21	1	14	0	2	1
0	0	0	0	0	0
7	0	3	0	0	0
2	0	2	1	0	0
6	0	0	0	0	0
0	0	0	0	0	0
15	1	20	2	0	0
5	0	0	0	0	0
3	0	0	1	0	0
0	0	0	0	0	0
5	0	1	0	0	0
0	0	0	0	0	0
1	0	1	1	0	0
12	0	7	1	0	0
2	0	0	0	0	0
7	0	0	0	0	0
4	0	0	0	0	0

EXECUTION TERMINATED BY CALL EXIT

440 LINES OUTPUT.
$PAUSE MORE JOBS TO FOLLOW
OPER. ACTION PAUSE

APPENDIX C

APPENDIX C

TABLE 16

WORKSHEET FOR TRIP PREDICTIONS
INTERVENING PARK

Park ______________ Design Year ___________

County	Distance (Road Miles)	Y (Trip Rate From Figure 29)	X Population (in Thousands)	=	Annual Trips
1.				=	
2.				=	
3.				=	
4.				=	
5.				=	
6.				=	
7.				=	
8.				=	
9.				=	
10.				=	
11.				=	
12.				=	
13.				=	
14.				=	
15.				=	
16.				=	
17.				=	

Annual Trips, Intervening Park =

TABLE 17

WORKSHEET FOR TRIP PREDICTIONS
CLOSEST PARK

Park ______________ Design Year ______________

County	Y (Road Miles)	X (Trip Rate From Figure 28)	Population (in Thousands)	=	Annual Trips
1.				=	
2.				=	
3.				=	
4.				=	
5.				=	
6.				=	
7.				=	
8.				=	
9.				=	
10.				=	
11.				=	
12.				=	
13.				=	
14.				=	
15.				=	
16.				=	
17.				=	

Annual Trips, Closest Park =

TABLE 18

WORKSHEET FOR TOTAL ANNUAL TRIPS

Park ____________	Design Year ____________
Annual trips, closest park	=
Annual trips, intervening park	=
Summation of Annual trips, closest and intervening parks	=
Total Annual Trips	= Summation of Annual Trips x 1.20
Total Annual Trips	= ________ x 1.20
	= ____________

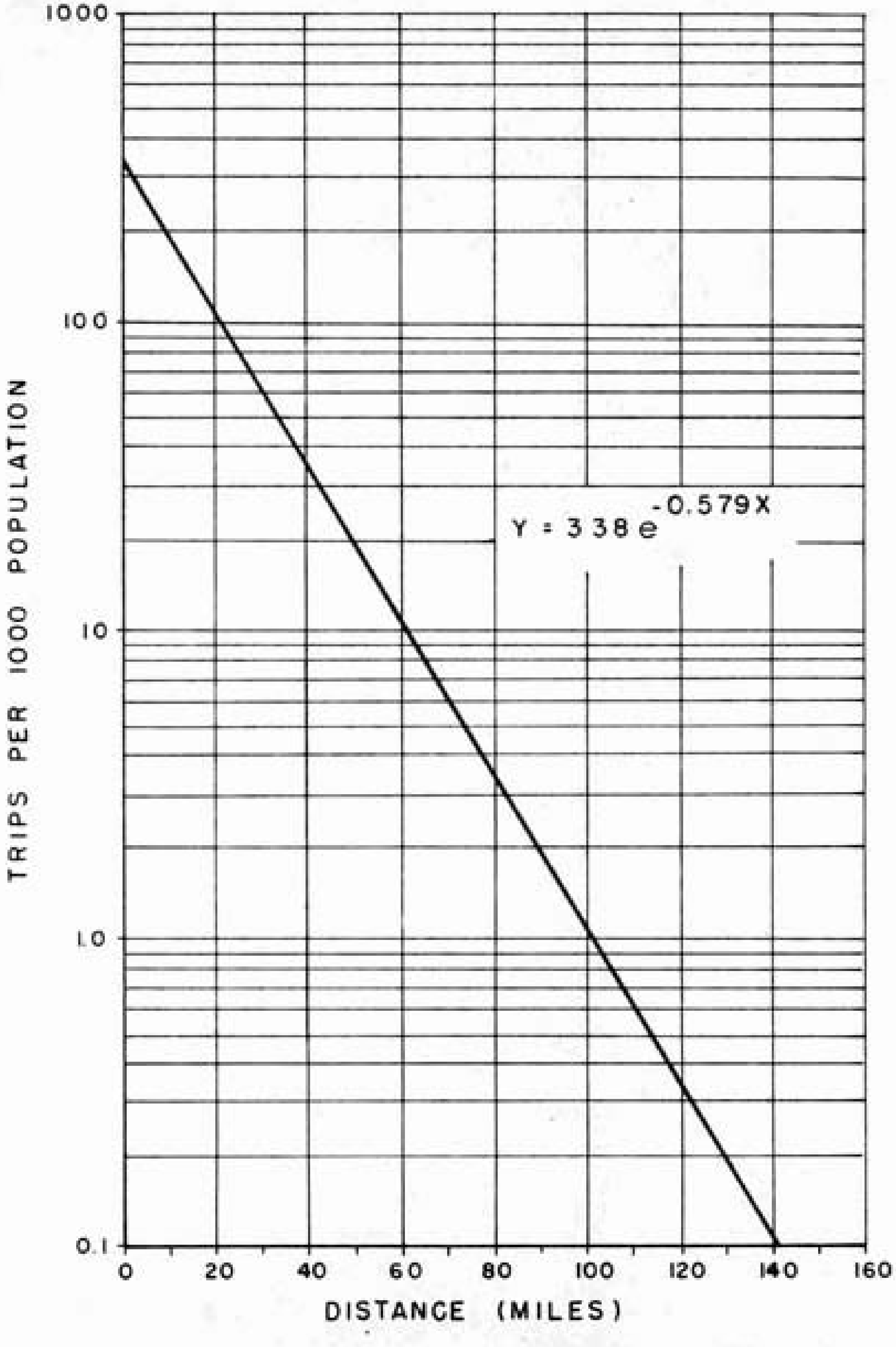

FIGURE 33
TOTAL TRIPS TO CLOSEST PARK

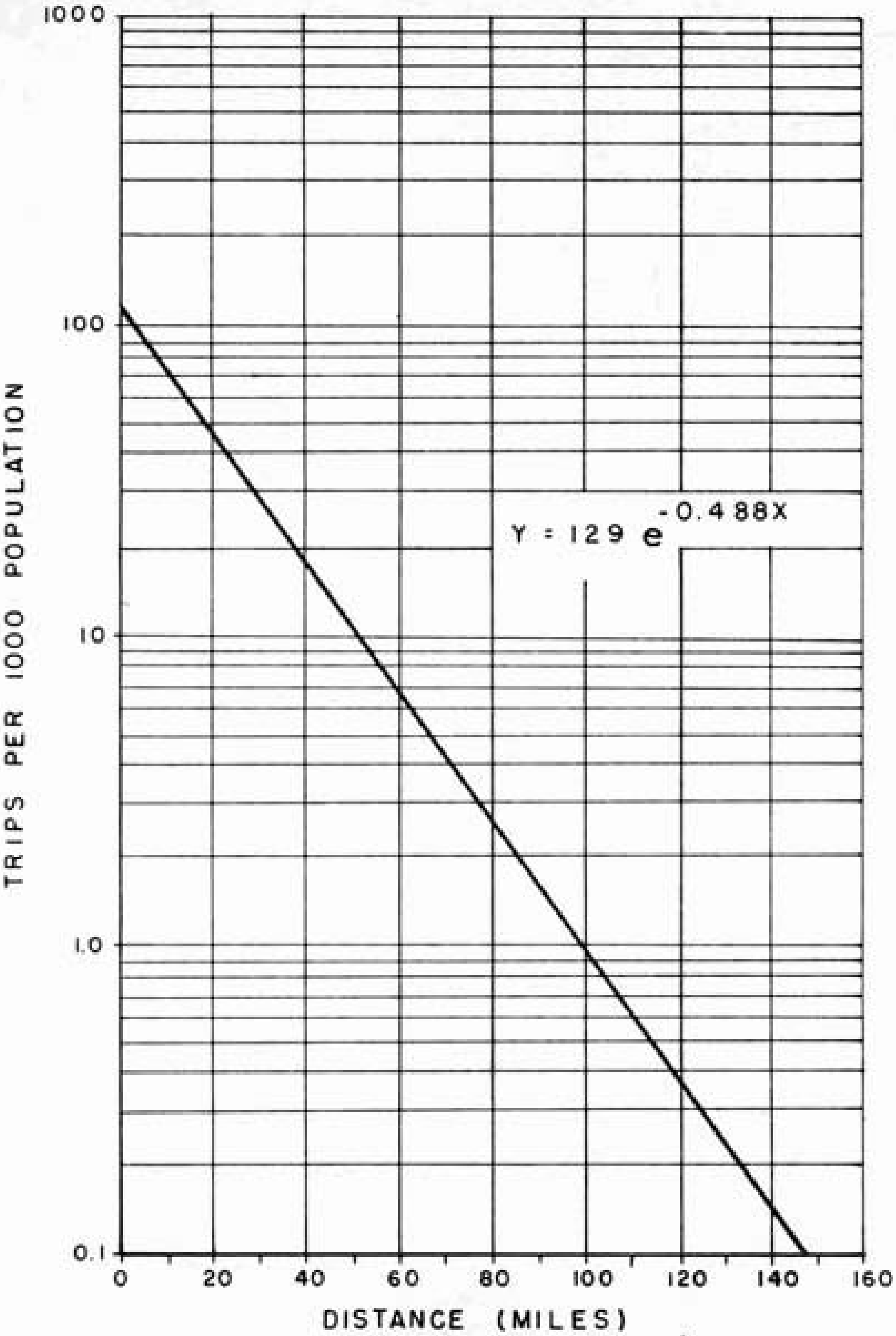

FIGURE 34
TOTAL TRIPS WITH INTERVENING PARK

VITA

VITA

Judson S. Matthias was born October 6, 1931 in Schofield Barracks, Hawaii. He attended high school at Institut auf den Rosenberg, St. Gallen, Switzerland, and was graduated from Washington-Lee High School, Arlington, Virginia.

He entered the United States Military Academy in 1950 and received his B.S. in 1954 and was commissioned a Second Lieutenant, United States Army. He received his M.S. degree in 1963 from Oregon State University.

In 1961, he was a graduate teaching assistant in the Department of Civil Engineering at Oregon State University and in 1962 he was appointed an instructor in that department. Since 1964, he has been an instructor at Purdue University. He completed the coursework required for the Ph.D. in the School of Civil Engineering at Purdue University in 1966.

He is a registered professional engineer in the State of Indiana, an associate member of the American Society of Civil Engineers, a member of the Purdue University Chapter, Institute of Traffic Engineers, and a member of the Professional Engineers of Oregon. He is a member of Sigma Xi honorary organization.